4th Quarterly Report (May - July 1999)

Periphyton-Based Stormwater Treatment Area (PSTA) Research and Demonstration Project

Prepared for

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Executive Summary

The South Florida Water Management District (District) is conducting research focused on potential advanced treatment technologies to support reduction of phosphorus loads in surface waters entering the remaining Everglades. Periphyton-based stormwater treatment areas (PSTAs) are one of the advanced treatment technologies being researched by the District. Prior to initiation of the District's PSTA project in July 1998, detailed research to evaluate treatment performance issues and the long-term viability of the PSTA approach to phosphorus reduction in Everglades Agricultural Area surface waters had not been performed.

Studies are being conducted in three of the south Everglades Nutrient Removal (ENR) test cells (PSTA Test Cells), and in 24 portable PSTA mesocosms (Porta-PSTAs). A second phase of research is planned under which PSTA feasibility will be evaluated further in larger-scale test systems (Field-Scale PSTAs). This document is an interim report of the PSTA study program contract held by CH2M HILL. It provides a brief summary of progress on the PSTA Research Project, with the primary focus on new information generated during the fourth project quarter (May through July 1999).

The purpose of this document remains primarily to transmit the new quarterly data. Preliminary mass loading and nutrient removal analyses are presented to introduce the anticipated final analytical approach. However, detailed data interpretation is being deferred until all four quarters of the Phase 1 data sets are available to support objective, technically defensible conclusions.

PSTA research activities during the first two quarters of the project were focused on development of a peer-reviewed, scientifically valid research plan and implementation of that plan through mesocosm design, construction, and testing. The operational startup of the three ENR PSTA Test Cells and the Porta-PSTA mesocosms occurred during the third quarter. The ENR PSTA Test Cells were filled to their operational levels, and inflows were adjusted to operational hydraulic loading rates on February 15, 1999. All test cell modifications were complete at that time. Operational monitoring of the PSTA Test Cells began on February 23, 1999. The Porta-PSTAs were adjusted to operational levels, and inflows and routine monitoring began on April 12, 1999.

Preliminary findings from the District's PSTA research are summarized as follows. Key results to date from the three PSTA Test Cells include:

- Inflow total phosphorus (TP) concentrations have been approximately one-half of anticipated levels, and have ranged from 0.018 to 0.025 milligrams per liter (mg/L) on a monthly average basis.
- Outflow TP concentrations have decreased each month in all treatments since startup. Average TP outflow concentrations were higher than inflow levels for the first 3 to 4 months of operation but have been below inflow levels during the last 2 months of the

quarter. Outflow concentrations in July averaged from 0.013 mg/L in the peat soil treatment and 0.014 to 0.017 mg/L in the shellrock treatments.

- Outflow soluble reactive phosphorus concentrations averaged between 0.002 and 0.003 mg/L in all three PSTA Test Cell treatments in July. The remaining TP in the test cell outflows is comprised of variable fractions of particulate and dissolved organic phosphorus forms.

- Estimated TP net mass removal rate constants have steadily increased since startup in all treatments. Based on a C* of 0.005 mg/L, average k values for July were 10 meters per year for the peat-based test cell, 8 m/y for the shellrock treatment with constant loading, and 1.4 m/y for the shellrock treatment with variable water regime.

- Influent total nitrogen (TN) concentrations decreased markedly during the operational period, with monthly averages declining from approximately 2.25 mg/L in February to 0.70 mg/L in July. Average outflow TN concentrations have also decreased, with concentrations between 0.44 and 0.65 mg/L in July.

- Influent concentrations of conductivity, total dissolved solids, and calcium have decreased since project startup.

- Soil TP storage has been relatively consistent since startup. The peat-based test cell had an estimated 15.8 grams per square meter (g/m^2). The shellrock test cells averaged between 118 to 120 g/m^2. Soil TP inventory has shown both positive and negative changes with no consistent trends. Very slight percentage TP losses from test cell soils could be contributing a significant fraction of the TP measured in water outflows.

- Plant cover in the PSTA Test Cells has increased throughout the operational period. This plant cover is dominated by macrophytes in all three treatments with more than 100 percent cover in the peat-based cell. Approximately 92 percent of this plant cover is comprised of submerged aquatic macrophytes, and emergent macrophytes cover approximately 18 percent of the cell. Periphytic algae are ubiquitous in the peat-based cell with an estimated cover of floating algal mats of approximately 17 percent in July. Total periphyton biomass in this cell was estimated as approximately 500 g ash-free dry weight (afdw) per m^2 in July. Chlorophyll *a* was estimated as 209 mg/m^2 in July, and algal biovolume as 16 cubic centimeters (cm^3) per m^2. Blue-green algae dominate the periphyton, and an average of 28 taxa were recorded in these counts.

- The shellrock-based cells have a lower plant cover by all plant species. Total cover was estimated as approximately 32 to 39 percent in these cells, and was dominated by submerged aquatics and emergent macrophytes. Periphyton occurs throughout these cells but floating mats cover only approximately 4 percent of each cell. Periphyton biomass was estimated as approximately 115 g afdw/m^2, and chlorophyll *a* was between 24 and 25 mg/m^2 in these cells in July. Blue-green taxa dominate the algal biovolume, which averaged between 2.4 and 3.0 cm^3/m^2. A total of 30 to 33 algal taxa were represented in these counts.

- Community metabolism estimates in the three PSTA Test Cell treatments were between 3 and 6 g $O_2/m^2/d$ during the period from May through July. All three cells have dissolved oxygen concentrations consistently greater than 6 mg/L.

Key results to date from the 24 Porta-PSTA mesocosms include:

- Inflow TP concentrations have been variable, and have ranged from 0.013 to 0.038 mg/L on a monthly average basis.
- Outflow TP concentrations have generally decreased each month in all treatments since startup. Outflow concentrations in July averaged from 0.013 to 0.018 mg/L.
- Outflow soluble reactive phosphorus concentrations averaged between 0.002 and 0.003 mg/L in all Porta-PSTA treatments in July. Dissolved organic phosphorus averaged approximately 0.005 mg/L in most mesocosm outlets in July.
- Estimated TP monthly average net mass removal rate constants peaked in June in all treatments. Based on a C* of 0.005 mg/L, average k values for June ranged from 9.3 to 34 m/y for the peat and shellrock treatments. Aquashade controls with very low populations of algae and macrophytes had average k values of 8.3 and 23 m/y during the same period. Sand-based sediment controls had k values of 2.5 and 13 m/y during June.
- Influent TN concentrations were variable during the operational period with monthly averages generally ranging from 0.82 to 1.48 mg/L. Average outflow TN concentrations in July were between 0.44 and 0.65 mg/L in the vegetated treatments.
- Influent concentrations of conductivity, total dissolved solids, and calcium were relatively consistent or increased since startup.
- Soil TP storage has been relatively consistent since startup. Sediment phosphorous concentrations in the peat-based mesocosms have averaged between 4.4 and 5.7 g/m^2. Shellrock phosphorus concentrations averaged between 105 to 135 g/m^2. Sand substrates had average phosphorus concentrations of 1.8 to 2.8 g/m^2. Soil TP inventory has shown both positive and negative changes with no consistent trends. Very slight percentage TP losses from mesocosm soils could be contributing a significant fraction of the TP measured in water outflows.
- Plant cover in the Porta-PSTA mesocosms has generally increased throughout the operational period in most treatments. This plant cover is dominated by planted macrophytes in the peat-based treatments and by floating periphytic mats in the other cells. Macrophytes and periphyton mats are growing faster in shallow than in deeper mesocosms.
- Total periphyton biomass in peat-based mesocosms was estimated as between 189 and 550 g afdw/m^2 in July. Chlorophyll *a* ranged from 37 to 48 mg/m^2. Algal biovolumes ranged from 1.9 to 4.8 cm^3/m^2 in July, and were dominated by blue-green periphyton species. An average of 26 to 34 algal taxa were represented in these counts in July.
- Total periphyton biomass in shellrock treatments was estimated as between 82 and 297 g afdw/m^2 in July. Chlorophyll *a* ranged from 14 to 151 mg/m^2. Algal biovolumes ranged from 3.3 to 65 cm^3/m^2 in July, and were dominated by blue-green periphyton species. An average of 25 to 37 algal taxa were represented in these counts in July.

- Community metabolism estimates in the Porta-PSTA treatments were between 0.67 and 3.9 g $O_2/m^2/d$ during the period from May through July. Estimates of net primary productivity in peat-based treatments were typically negative, in spite of evident plant community development. This observation indicates that there is a high sediment oxygen demand (SOD) in these peat-based systems. The peat-based aquashade control was used to estimate this SOD as approximately 1.14 g $O_2/m^2/d$. The SOD estimated from the shellrock aquashade control was 0.04 g $O_2/m^2/d$.

Operation and monitoring of the PSTA mesocosms past July 1999 is scheduled to continue for at least 7 more months for the three PSTA Test Cells and 9 more months in the Porta-PSTAs. Results through the first operational quarter were largely influenced by startup conditions, including soil phosphorus releases and plant community succession and development. Very low phosphorus loadings have provided insight into system operation under unusual conditions. Continuing monitoring of the PSTA experimental systems will be necessary to identify the effects of seasonal variability, ecosystem maturity, and response to higher TP loadings.

of the anticipated Phase 1 final report, and therefore are considered an early implementation of the work authorized under the contract as Task 10.

It should be clearly understood that while the cumulative data are being presented, the purpose of this document remains primarily to transmit the new quarterly data. Preliminary mass loading and nutrient removal analyses are presented to introduce the anticipated final analytical approach. However, detailed data interpretation is being deferred until all four quarters of the Phase 1 data sets are available to support objective, technically defensible conclusions. Completion of the 1-year field studies anticipated under Phase 1 will provide the District with a clearer picture on how seasonality affects PSTA "functionality". Therefore, the interim data presented in this report merely serve to document the continuation of monitoring efforts and are not yet appropriate for supporting conclusions regarding PSTA viability.

Lastly, it should be noted that the information contained in this document remains preliminary and draft. Complete quality control (QC) review of all data sets has not been conducted on all of the information being transmitted (some of it was only recently received from the various analytical support laboratories). In fact, some data sets for this quarter have yet to be completely reported by those laboratories. Any data identified during our QC reviews that should be flagged or qualified will be documented in the two remaining Phase 1 quarterly reports or a final Phase 1 report, as applicable.

1.2 Summary of Progress During Previous Quarters

PSTA research activities during the first two quarters of the project were focused on development of a peer-reviewed, scientifically valid research plan and implementation of that plan through mesocosm design, construction, and testing. The operational startup of the three ENR PSTA Test Cells and the Porta-PSTA mesocosms occurred during the third quarter. This section provides a bulletized summary of key activities during the first three quarters of project activity.

1.2.1 First Project Quarter—July 1998 through October 1998

- Scientific Research Panel (SRP) members subcontracted and scheduled to review the PSTA Research Plan.
- Preliminary Draft PSTA Research Plan was prepared and submitted to District for review and comment.
- Draft PSTA Research Plan was revised and sent to SRP members prior to the review meeting.
- PSTA SRP review meeting was held at District headquarters in West Palm Beach.
- Oral and written comments on the PSTA Research Plan were received and incorporated in the revised Draft PSTA Research Plan dated October 1998.

1.2.2 Second Project Quarter—November 1998 through January 1999

- Conducted design and contracting for Porta-PSTA construction

- Conducted design of modifications to ENR PSTA Test Cells and implementation of plant growth inhibition activities
- Developed Porta-PSTA layout at South ENR Supplemental Technologies Research Compound (STRC)
- Delivered and set up Porta-PSTAs including site plumbing, leak-testing, sediment installation, macrophyte planting, and algae seeding
- Delivered and set up PSTA field trailer at South ENR STRC
- Modified ENR PSTA Test Cells to include inlet and outlet distribution enhancement, installation of monitoring walkways, installation of horizon markers, and macrophyte planting
- Developed final methods for water regime fluctuations, periphyton and sediment coring, percent cover estimates, light attenuation studies, and community metabolism studies
- Conducted analytical testing of PSTA sediments for phosphorus sorption/desorption characteristics and inclusion of sand-based controls in Porta-PSTA design

Several of the activities started during the second quarter continued into the third project quarter because of the need for some Porta-PSTA mesocosm leak-proofing and repairs. While this delayed field research startup, this had the side benefit of providing additional time for establishment and growth of the *Eleocharis* sp. planted in both mesocosm types before raising water in the mesocosms to target water levels for operation. In addition, deferral of operational startup reduced the challenge of trying to get the periphyton system operational during the normally least-productive season for periphytic algal growth.

1.2.3 Third Project Quarter—February 1999 through April 1999

- The ENR PSTA Test Cells were filled to their operational levels, and inflows were adjusted to operational hydraulic loading rates on February 15, 1999. All Test Cell modifications were complete at that time. Operational monitoring of the PSTA Test Cells began on February 23, 1999.
- The Porta-PSTAs were adjusted to operational levels, and inflows and routine monitoring began on April 12, 1999.
- Tracer study methodology was evaluated for the Porta-PSTA system.
- The first operational data summary covering results from the Third Project Quarter was issued in July 1999.

1.3 Operational Highlights During the Fourth Project Quarter

Routine operation and monitoring of the PSTA Test Cells and the Porta-PSTA mesocosms was continued throughout the fourth project quarter from May through July 1999. Several operational challenges occurred during this period that may affect the following results:

- The water supply pumps serving the ENR South STRC became nonfunctional on June 10, 1999. Because of the uncertainty related to repairs, CH2M HILL installed a temporary water delivery system to the Porta-PSTA mesocosms.
- A tracer study was conducted in selected Porta-PSTA mesocosms between April 19, 1999, and June 15, 1999. Both lithium and bromide were used as tracer elements. Results of this special study are included in this report.
- A lithium tracer study was initiated in the three PSTA Test Cells on July 29, 1999.
- The Porta-PSTA inflow valves are clogging with fine particulates on an irregular basis. This clogging appears to be the result of solids entrained at the pump station withdrawing water from the ENR discharge canal, and because of the extremely low inflow rates being used for these mesocosms. A relatively coarse screen has been installed between the head tank and inlet manifolds leading to the mesocosms. This screen has not been entirely effective at preventing clogging. Inflows were increased in the lowest hydraulic loading rate treatments to attempt to overcome this problem.

1.4 Summary of Experimental Design

1.4.1 South ENR Test Cells

The District assigned three Test Cells within the South ENR STRC to the PSTA Research Project. During final construction, substrate within these PSTA Test Cells was modified by the District by placing the following layers of substrate over the cell liner:

- **Test Cell 13:** 2.5 feet (ft) of sand surcharge plus 1.0 ft of shellrock (locally mined) plus 1.0 ft of peat (taken from area of STA 1W, Cell 5 – unflooded, former agriculturally worked lands)
- **Test Cell 8:** 3.5 ft of sand surcharge plus 1.0 ft of shellrock (locally mined)
- **Test Cell 3:** 3.5 ft of sand surcharge plus 1.0 ft of shellrock (locally mined)

Exhibit 1-1 provides a plan view of a typical PSTA Test Cell showing sampling locations and walkways. Exhibit 1-2 provides a summary of detailed design criteria for the PSTA Test Cells. Exhibits 1-3a, b, and c are aerial photographs of Test Cells 13, 8, and 3, respectively, taken on September 29, 1999.

1.4.2 Porta-PSTA Mesocosms

Twenty-four Porta-PSTA mesocosm units were fabricated of fiberglass offsite and delivered to the South STRC. Twenty-two of the fiberglass tanks are 6 meters long by 1 meter wide by 1 meter deep. The remaining two tanks are 3 meters wide to allow assessment of mesocosm configuration effects.

Exhibit 1-4 provides an aerial view of the Porta-PSTA experimental site showing the layout of the 24 mesocosms in relation to the onsite laboratory trailer and other facilities the District has within this compound. Detailed design and operational criteria for the Porta-PSTAs are summarized in Exhibit 1-5.

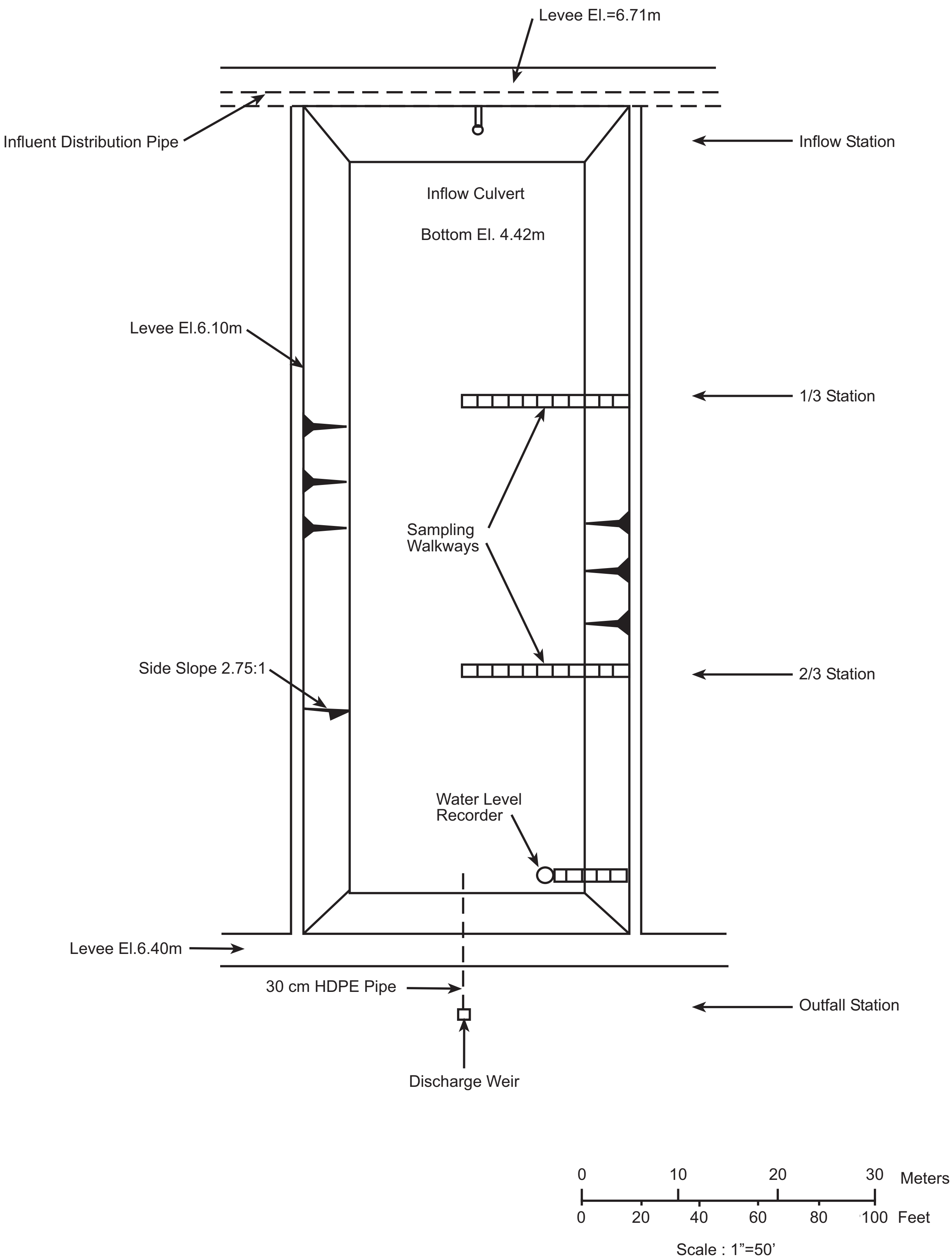

Exhibit 1-1. Plan View of Typical ENR PSTA Test Cell Showing Sampling Locations

SECTION 1

Introduction

1.1 Background

The South Florida Water Management District (District) is conducting research focused on potential advanced treatment technologies to support reduction of phosphorus loads in surface waters entering the remaining Everglades. Particular focus is being placed on the treatment of excess surface waters from the Everglades Agricultural Area (EAA) as well as Lake Okeechobee water that is diverted through the primary canal system to the Lower East Coast of Florida.

Periphyton-based stormwater treatment areas (PSTAs) are one of the advanced treatment technologies being researched by the District. The PSTA concept was proposed for phosphorus removal from EAA waters by Doren and Jones (1996) and further described and evaluated by Kadlec (1996, 1998) and Kadlec and Walker (1996). Prior to initiation of the District's PSTA project in July 1998, detailed research to evaluate treatment performance issues and the long-term viability of the PSTA approach to phosphorus reduction in EAA surface waters had not been performed.

The two phases of the PSTA research and demonstration project are described in detail in the *Experimental Research Plan* (CH2M HILL, 1999). In brief, the first phase of the study is to provide basic research data needed to better understand whether the PSTA concept should continue to be investigated as a part of the solution for Everglades restoration. Phase 1 research is being performed through field-based mesocosm experiments located within the District's Everglades Nutrient Removal (ENR) Project. Studies are being conducted in 24 portable PSTA mesocosms (Porta-PSTAs), and in three of the south ENR Test Cells. A second phase of research is planned under which PSTA feasibility will be evaluated further in larger-scale mesocosms. Although preliminary research plan concepts for Phase 2 have been outlined in the *Experimental Research Plan*, they remain dynamic in light of the high level of interest in expediting the overall schedule for evaluating and integrating advanced treatment technologies into the Stormwater Treatment Area (STA) system design for the EAA.

This document is an interim report prepared under Task 9 of the PSTA study program contract held by CH2M HILL. It provides a brief summary of progress on the PSTA Research Project, with the primary focus on new information generated during the fourth quarter (May through July 1999). However, it should be noted that the data summaries presented are cumulative to provide a clear overview of all data generated under the field program to date. While this approach varies somewhat from that specified under Task 9 in the project scope of work, this comprehensive overview approach was considered likely to be more useful as the District tracks the growing database available and makes decisions relevant to the potential acceleration of Phase 2 of the PSTA research program. The cumulative data summaries are viewed as products that would have been needed for preparation

Exhibit 1-2
Summary of Detailed Design Criteria for ENR PSTA Test Cells

Design Parameter	Treatment 1 Cell 13	Treatment 2 Cell 8	Treatment 3 Cell 3	Combined System
No. Cells	1	1	1	1
Flow (m^3/d)				
Average	134	134	134	269
Maximum	134	134	269	403
Minimum	134	134	1	135
Cell Length (m)	80.0	80.0	80.0	80.0
Cell Width (m)	28.0	28.0	28.0	28.0
Aspect Ratio	2.9	2.9	2.9	2.9
Area (m^2)				
Horizontal surface area	2240.0	2240.0	2240.0	4480
Wall Area (@ design depth)	129.6	129.6	64.8	194
Operational Water Depth (m)				
Average	0.60	0.60	0.30	0.45
Maximum	0.60	0.60	1.00	0.80
Minimum	0.60	0.60	0.01	0.31
Operational Water Volume (m^3)				
Average	1344.0	1344.0	672.0	2016
Maximum	1344.0	1344.0	2240.0	3584
Minimum	1344.0	1344.0	22.4	1366
Nominal Hydraulic Residence Time (d)				
@ average flow and depth	10.00	10.00	5.00	7.50
@ maximum flow and minimum depth	10.00	10.00	0.08	3.39
@minimum flow and maximum depth	10.00	10.00	2240.00	26.47
Hydraulic Loading Rate (cm/d)				
@ average flow and depth	6.0	6.0	6.0	6.0
@ maximum flow	6.0	6.0	12.0	9.0
@minimum flow	6.0	6.0	0.0	3.0
Nominal Linear Velocity (m/d)				
@ average flow and depth	8.00	8.00	16.00	21.33
@ maximum flow and minimum depth	8.0	8.0	960.0	47.2
@minimum flow and maximum depth	8.00	8.00	0.04	6.04
Substrate				
Surface	Peat	Shellrock	Shellrock	Peat/Shellrock
Bottom	Shellrock	Shellrock	Shellrock	Shellrock
Construction Material	Earth	Earth	Earth	Earth
Liner (Yes/No)	Yes	Yes	Yes	Yes
Freeboard (m)				
@ average depth	1.38	1.38	1.68	1.53
Deep Zones				
Number per Cell	0	0	0	0
Depth Below Floor Elevation (m)	NA	NA	NA	NA
Plant Species (Yes/No)				
Periphyton	Yes	Yes	Yes	Yes
Macrophytes	Yes	Yes	Yes	Yes
None (Aquashade Control)	No	No	No	No
Design TP Influent Quality (µg/L)				
Average	40	40	40	40
Maximum	50	50	50	50
Minimum	30	30	30	30
Design TP Mass Loading (g/m^2/y)				
Average	0.88	0.88	0.88	0.88
Maximum	1.10	1.10	1.10	1.10
Minimum	0.66	0.66	0.66	0.66

Notes:
m = meters
m^3/d = cubic meter(s) per day
m^2 = square meter(s)
cm/d = centimeter(s) per day
g/m^2/y = gram(s) per square meter per year
µg/L = microgram(s) per liter

EXHIBIT 1-3A
Aerial Photograph of South ENR Test Cell 13

EXHIBIT 1-3B
Aerial Photograph of South ENR Test Cell 8

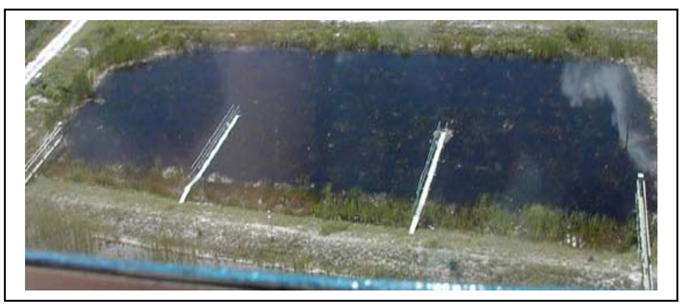

EXHIBIT 1-3C
Aerial Photograph of South ENR Test Cell 3

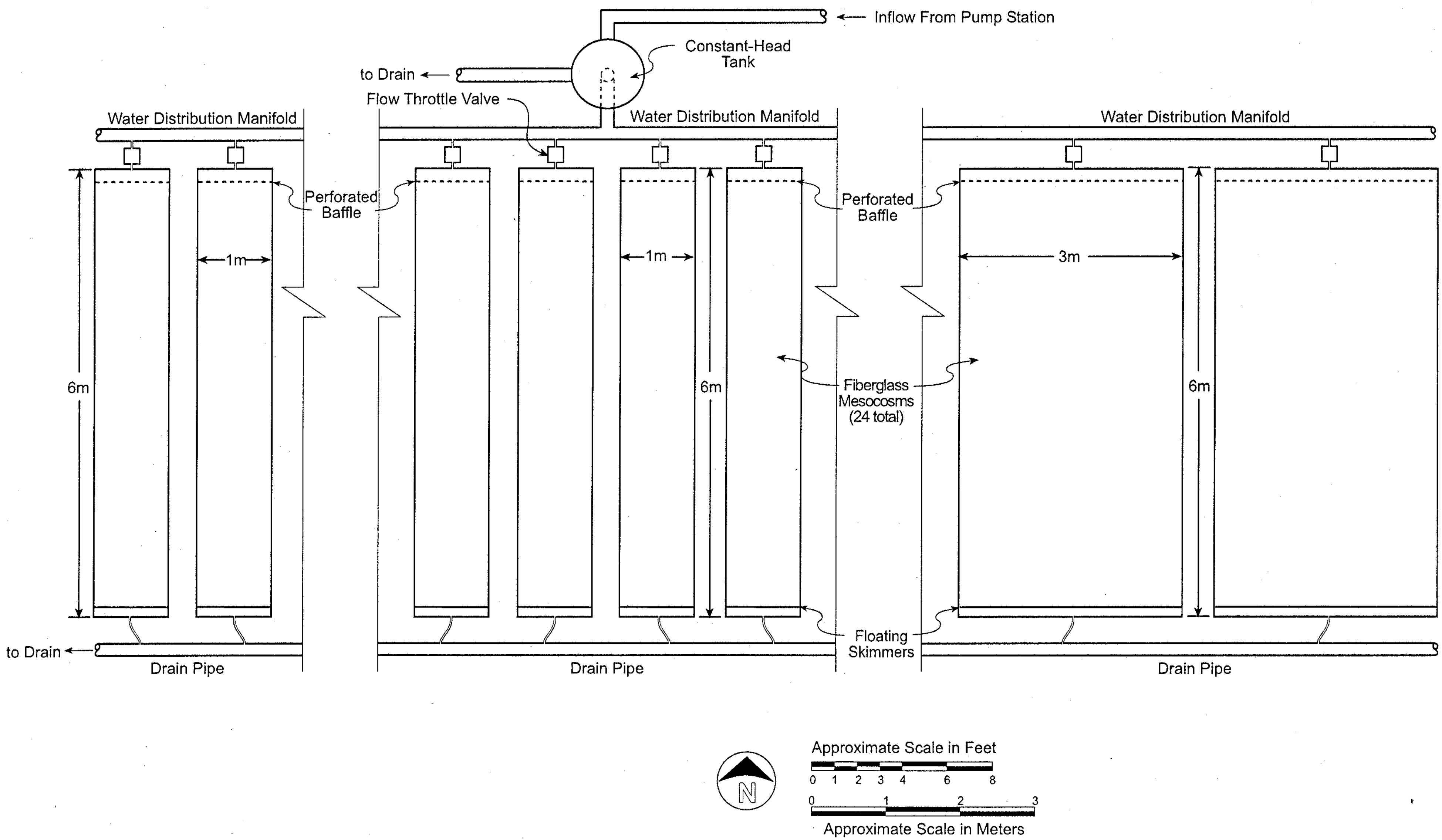

Exhibit 1-4. Porta-PSTA Experimental Mesocosm Site Plan

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Exhibit 1-5
Summary of Design Criteria for Porta-PSTA Experimental Mesocosms

Design Parameter	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6	Treatment 7	Treatment 8	Treatment 9	Treatment 10	Treatment 11	Treatment 12	Combined System
No. Cells	3	3	3	3	3	3	1	1	1	1	1	1	24
Flow (m^3/d)													
Average	0.36	0.36	0.36	0.36	0.72	0.36	0.36	0.36	0.36	0.36	1.08	1.08	11.16
Maximum	0.36	0.36	0.36	0.36	0.72	0.72	0.72	0.36	0.36	0.36	1.08	1.08	12.60
Minimum	0.36	0.36	0.36	0.36	0.72	0.05	0.05	0.36	0.36	0.36	1.08	1.08	9.92
Flow (mL/min)													
Average	250	250	250	250	500	250	250	250	250	250	750	750	7750
Maximum	250	250	250	250	500	500	500	250	250	250	750	750	8749
Minimum	250	250	250	250	500	35	35	250	250	250	750	750	6888
Cell Depth (m)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Cell Length (m)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Cell Width (m)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	3.00	1.33
Length:Width Ratio	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	2.0	2.0	4.5
Water Depth:Width Ratio	0.6	0.6	0.3	0.3	0.6	0.3	0.3	0.6	0.6	0.6	0.1	0.1	0.34
Area (m^2)													
Horizontal surface area	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	18.00	18.00	168.00
Wall Area (@ design depth)	8.40	8.40	4.20	4.20	8.40	4.20	4.20	8.40	8.40	8.40	5.40	5.40	153.60
Operational Water Depth (m)													
Average	0.60	0.60	0.30	0.30	0.60	0.30	0.30	0.60	0.60	0.60	0.30	0.30	0.45
Maximum	0.60	0.60	0.30	0.30	0.60	0.60	0.30	0.60	0.60	0.60	0.30	0.30	0.48
Minimum	0.60	0.60	0.30	0.30	0.60	0.01	0.30	0.60	0.60	0.60	0.30	0.30	0.43
Operational Water Volume (m^3)													
Average	3.60	3.60	1.80	1.80	3.60	1.80	1.80	3.60	3.60	3.60	5.40	5.40	72.00
Maximum	3.60	3.60	1.80	1.80	3.60	3.60	1.80	3.60	3.60	3.60	5.40	5.40	77.40
Minimum	3.60	3.60	1.80	1.80	3.60	0.06	1.80	3.60	3.60	3.60	5.40	5.40	66.78
Nominal Hydraulic Residence Time (d)													
@ average flow and depth	10.00	10.00	5.00	5.00	5.00	5.00	5.00	10.00	10.00	10.00	5.00	5.00	6.45
@ maximum flow and minimum depth	10.00	10.00	5.00	5.00	5.00	0.08	5.00	10.00	10.00	10.00	5.00	5.00	5.30
@minimum flow and maximum depth	10.00	10.00	5.00	5.00	5.00	72.00	5.00	10.00	10.00	10.00	5.00	5.00	7.80
Hydraulic Loading Rate (cm/d)													
@ average flow and depth	6.0	6.0	6.0	6.0	12.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.6
@ maximum flow	6.0	6.0	6.0	6.0	12.0	12.0	6.0	6.0	6.0	6.0	6.0	6.0	7.5
@minimum flow	6.0	6.0	6.0	6.0	12.0	0.8	6.0	6.0	6.0	6.0	6.0	6.0	5.9
Nominal Linear Velocity (m/d)													
@ average flow and depth	0.60	0.60	1.20	1.20	1.20	1.20	1.20	0.60	0.60	0.60	1.20	1.20	0.95
@ maximum flow and minimum depth	0.60	0.60	1.20	1.20	1.20	72.00	1.20	0.60	0.60	0.60	1.20	1.20	6.85
@minimum flow and maximum depth	0.60	0.60	1.20	1.20	1.20	0.08	1.20	0.60	0.60	0.60	1.20	1.20	0.86
Substrate Depth (m)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.20
Substrate Type	Peat	Shellrock	Peat	Shellrock	Shellrock	Shellrock	Sand	Sand	Peat	Shellrock	Shellrock	Shellrock	Peat/Shellrock
Construction Material	Fiberglass	Fiberglass	Fiberglass	Fiberglass	Fiberglass	Fiberglass	Fiberglass	Fiberglass	Fiberglass	Fiberglass	Fiberglass	Fiberglass	Fiberglass
Liner (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Freeboard (m)													
@ average depth	0.10	0.10	0.40	0.40	0.10	0.40	0.40	0.10	0.10	0.10	0.40	0.40	0.25
Plant Species (Yes/No)													
Periphyton	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes/No
Macrophytes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes/No
None (Aquashade Control)	No	No	No	No	No	No	No	No	Yes	Yes	No	No	Yes/No
Design TP Influent Quality (µg/L)													
Average	40	40	40	40	40	40	40	40	40	40	40	40	40
Maximum	50	50	50	50	50	50	50	50	50	50	50	50	50
Minimum	30	30	30	30	30	30	30	30	30	30	30	30	30
Design TP Mass Loading (g/m^2/y)													
Average	0.88	0.88	0.88	0.88	1.75	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.97
Maximum	1.10	1.10	1.10	1.10	2.19	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.21
Minimum	0.66	0.66	0.66	0.66	1.31	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.73

Notes:
m = meters
mL/min = milliliter(s) per minute
m^3/d = cubic meter(s) per day
m^2 = square meter(s)
cm/d = centimeter(s) per day
g/m^2/y = gram(s) per square meter per year
µg/L = microgram(s) per liter

SECTION 2
Meteorological Data

2.1 Solar Radiation

Solar radiation is being continuously monitored by CH2M HILL at the South ENR STRC using a pyranometer and phostosynthetically active radiation (PAR) quantum sensor mounted above the constant-head water tank. Exhibits 2-1 and 2-2 illustrate total solar radiation and PAR, respectively, at this site for the third and fourth quarters. PAR and total insolation monitored during the third quarter averaged 39.16 Einstein per square meter per day (E/m²/d) and 20.50 megajoules per square meter per day MJ/m²/d, respectively. In the fourth quarter, PAR and total insolation averaged 39.26 E/m²/d and 21.29 MJ/m²/d, respectively. Total insolation and PAR were lower during June than in May and July.

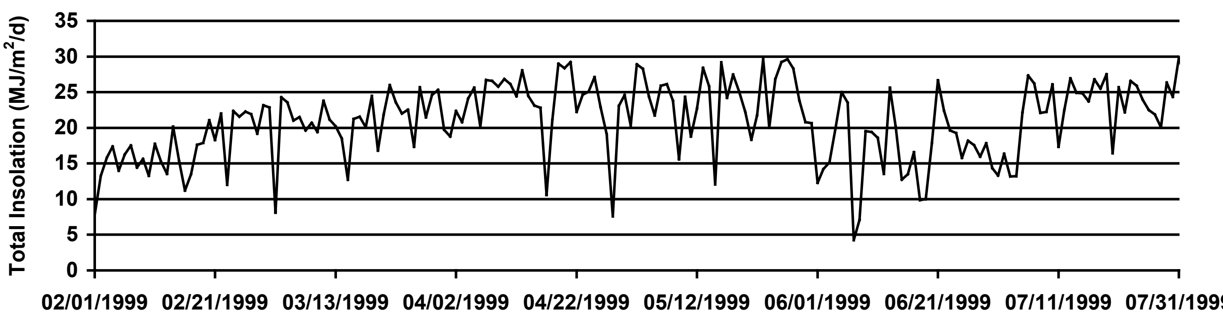


EXHIBIT 2-1
Total Solar Radiation Measured at the South ENR STRC

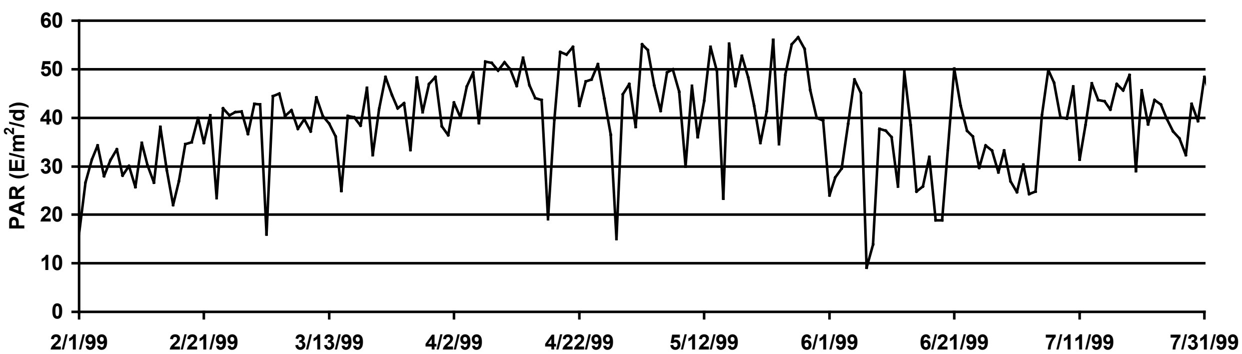


EXHIBIT 2-2
Photosynthetically Active Radiation Measured at the South ENR STRC

2.2 Air Temperature

On May 29, 1999, CH2M HILL initiated continuous monitoring of air temperature at the South ENR STRC. An air temperature probe is mounted above the constant-head water tank along with the solar radiation equipment. Air temperature averaged 25.6, 25.0, and 27.1 degrees C during the May, June, and July study periods, respectively. Exhibit 2-3 presents average air temperatures recorded at the South ENR STRC.

2.3 Rainfall

Daily rainfall data were provided by the District. Exhibit 2-4 illustrates daily total rainfall at the ENR Rainfall Station ENR301 for the February through July 1999 study period. Rainfall during the third and fourth quarters totaled 2.00 inches and 17.81 inches, respectively. Rainfall in June was higher than in any other month since operational monitoring began in February. High rainfall during June and associated cloudy sky conditions explain the low solar insolation and temperature averages observed for this month.

2.4 Evapotranspiration

Daily evapotranspiration (ET) data were provided by the District. Exhibit 2-5 illustrates daily total ET at the ENR Evapotranspiration Station ENRP for the February through May 1999 study period. Estimated ET during the third quarter totaled 12.74 inches. Daily ET data for the last 2 months of the fourth quarter (June through July 1999) are not yet available from the District. However, May 1999 ET totaled 5.41 inches.

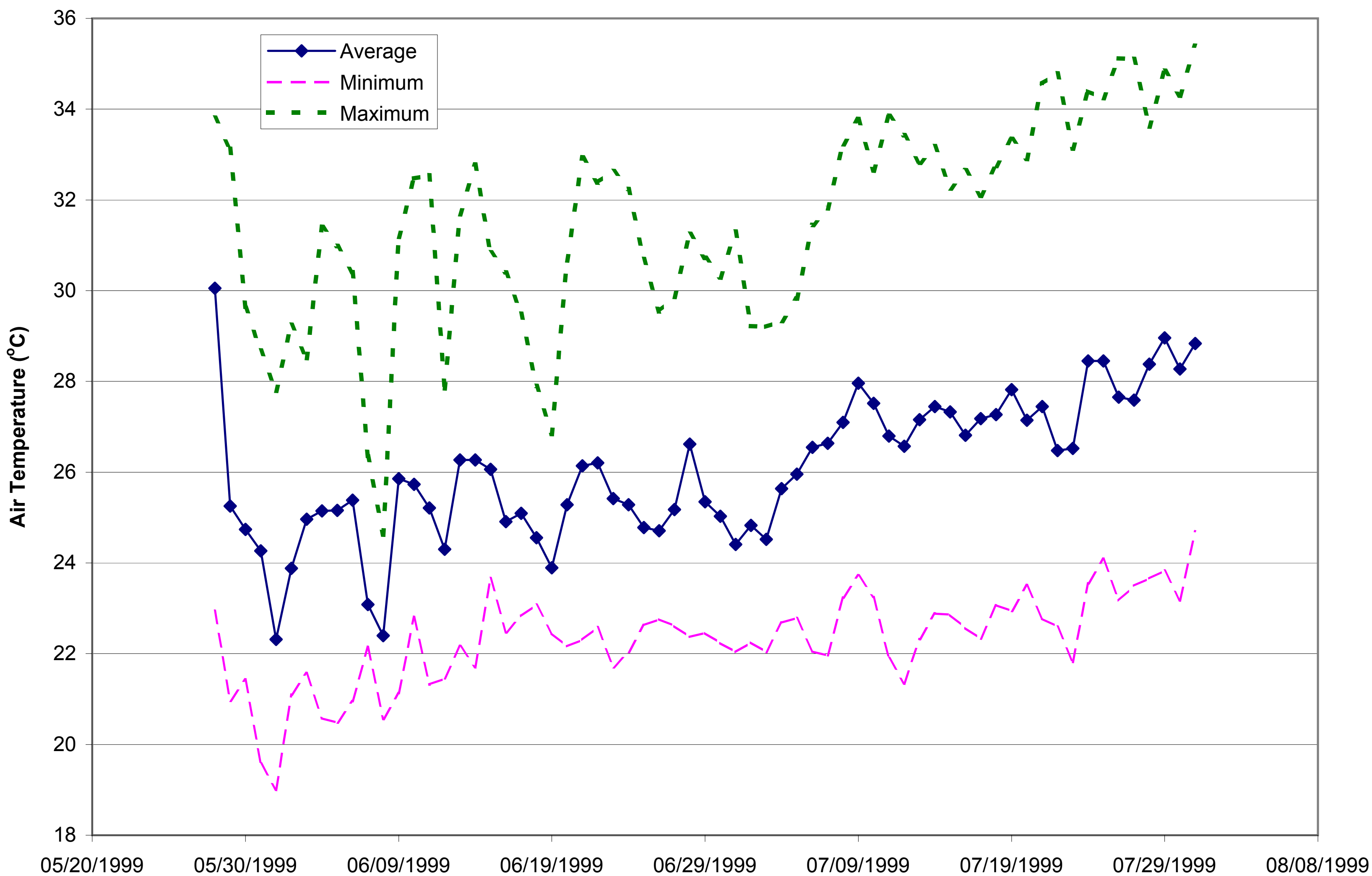


EXHIBIT 2-3
Average Daily Air Temperature Data at the South ENR STRC

DFB/Ex Sct 2.xls

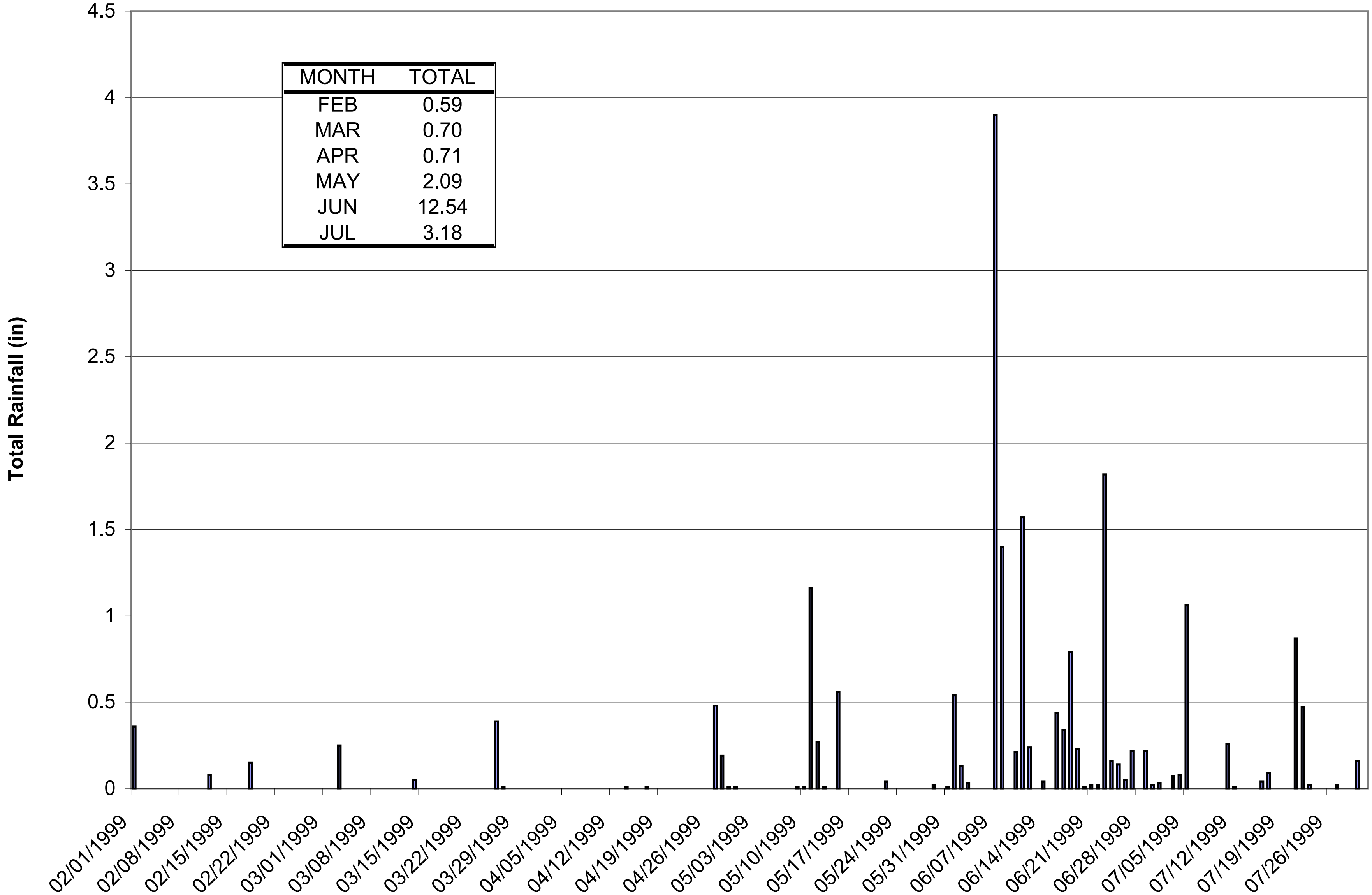
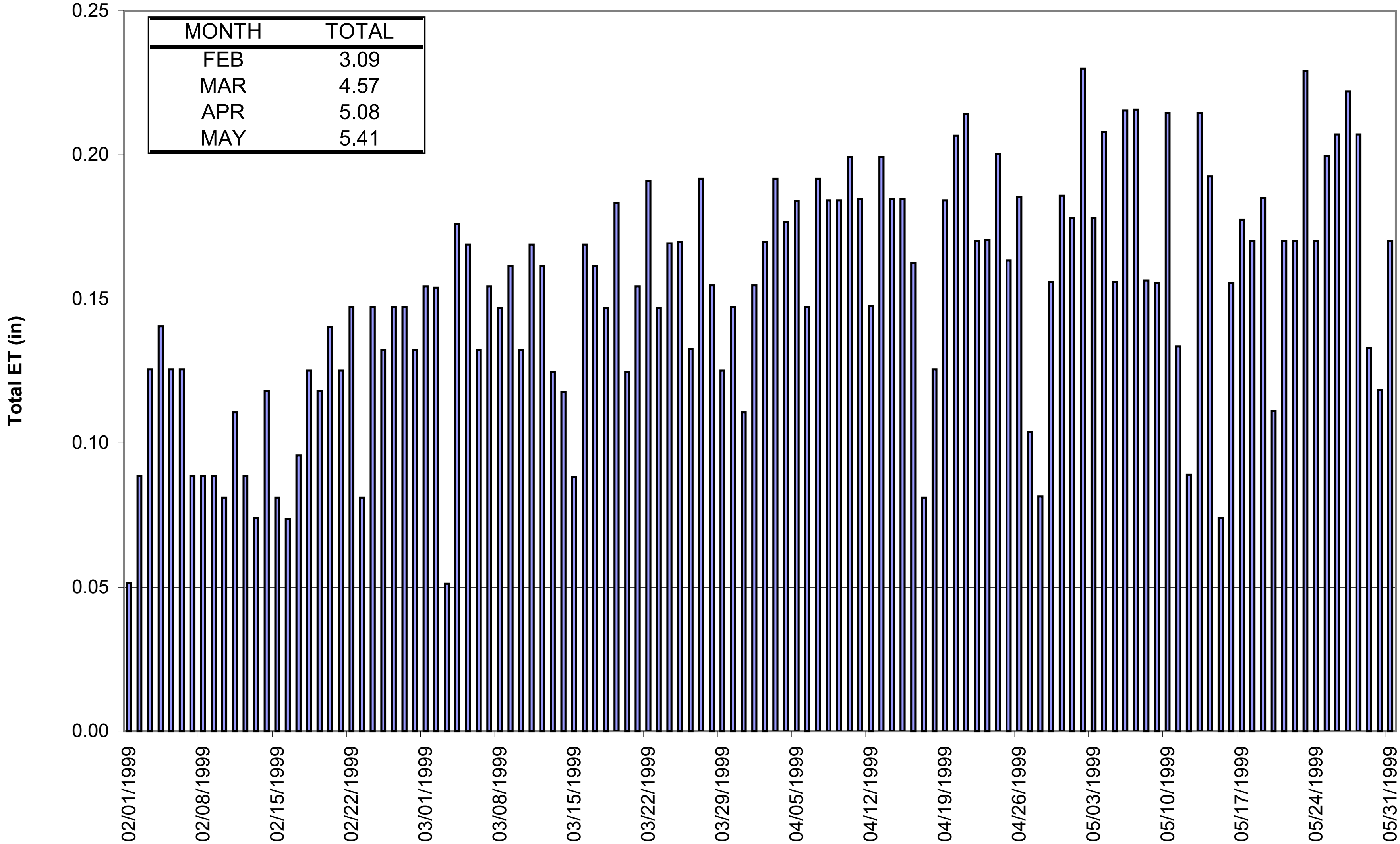


EXHIBIT 2-4
Daily Rainfall Data at the ENR Rainfall Station ENR301



MONTH	TOTAL
FEB	3.09
MAR	4.57
APR	5.08
MAY	5.41

EXHIBIT 2-5
Daily Evapotransporation Data at the ENR Evapotranspiration Station ENRP

DFB/Ex Sct 2.xls

SECTION 3

ENR PSTA Test Cells

3.1 PSTA Treatments at the ENR South Test Cells

Exhibit 3-1 provides a summary of the three experimental treatments being examined at the South ENR PSTA Test Cells.

EXHIBIT 3-1
Experimental Treatments in the ENR PSTA Test Cells

	Substrate	Periphyton	Macrophytes	Water Depth (cm)	HLR (cm/d)	# Replicates
Treatment						
1 (Cell 13)	Peat	Yes	Yes	60	6	1
2 (Cell 8)	Shellrock	Yes	Yes	60	6	1
3 (Cell 3)	Shellrock	Yes	Yes	0–60	6	1
					Total Cells =	**3**

3.2 Water Regime

The PSTA water regime includes the components of water depth fluctuations, hydraulic loading rate, and water mass balance. Continuous water level recorders were installed by the District at the upstream and downstream ends of each of the ENR Test Cells during this quarter. Data summaries for these instruments will be provided in the 5th Quarterly Report. Exhibit 3-2 summarizes the PSTA Test Cell water regime data for the 3rd and 4th Quarters. Water level, inflow, outflow, and hydraulic loading rate (HLR) charts are presented in Appendix A.

3.2.1 Water Depth

Water level measurements in the PSTA Test Cells were recorded at the District staff gauge near the outflow of each Test Cell. Readings were taken weekly or more frequently. Continuous stage records were available for the Head Cell. These stage data were provided by the District.

3.2.2 Hydraulic Loading Rate

The HLR, q, is calculated using the following equation:

$$q\ (m/d) = Q/A \qquad \text{Equation 1}$$

Where:

Q = volumetric flow rate (m^3/d)

A = wetted area of the cell (m^2)

Exhibit 3-2
Water Regime Data at the South ENR Test Cells, February through July 1999

Parameter	Summary Statistic	Treatment (Test Cell) 1 (Cell 13) Feb - Apr 99	1 (Cell 13) May - Jul 99	2 (Cell 8) Feb - Apr 99	2 (Cell 8) May - Jul 99	3 (Cell 3) Feb - Apr 99	3 (Cell 3) May - Jul 99
Water Depth (m)	Avg	0.58	0.64	0.57	0.63	0.61	0.63
	Max	0.66	0.74	0.69	0.69	0.73	0.82
	Min	0.35	0.41	0.33	0.48	0.41	0.33
	Std Dev	0.11	0.06	0.11	0.03	0.10	0.20
	n	23	34	23	34	23	34
Inflow (m^3/d)	Avg	137.81	144.68	137.81	144.68	124.82	120.67
	Max	153.08	144.91	153.08	144.91	153.08	144.91
	Min	51.61	144.43	51.61	144.43	51.61	77.26
	Std Dev	18.91	0.19	18.91	0.19	30.48	32.21
	n	8343	10	8343	10	8343	10
Outflow (m^3/d)	Avg	115.67	152.02	123.76	135.78	203.62	113.90
	Max	191.14	203.52	191.14	176.78	699.23	162.01
	Min	62.63	43.81	53.30	71.02	0.00	38.62
	Std Dev	31.50	47.55	31.25	36.03	193.43	49.24
	n	15	10	15	10	17	10
HLR (cm/d)	Avg	5.30	5.49	5.29	5.52	4.75	4.53
	Max	6.25	5.55	6.20	5.65	6.14	5.34
	Min	1.95	5.39	1.97	5.47	1.92	3.12
	Std Dev	0.75	0.05	0.74	0.05	1.15	1.02
	n	2000	10	2000	10	2000	10

Water inflows to the PSTA Test Cells are estimated with an empirical equation (Equation 2) provided by the District that is based upon inlet orifice diameter and the water stage in the Head Cell feeding the three PSTA Test Cells:

$$Qin\ (cfs) = [stage\ (ft)*A] - B \qquad \text{Equation 2}$$

Where:

0.75-inch orifice: A = 0.004561, B = 0.07561
1.0-inch orifice: A = 0.008587, B = 0.14266

Outflows from the PSTA Test Cells were estimated by applying a standard flow equation for the 90-degree V-notch weirs at each outlet. The height at the water over the weir (H) is calculated by reading the staff gauge in the weir box and is used in Equation 3:

$$Q_{out}\ (cfs) = 2.50*H^{2.5} \qquad \text{Equation 3}$$

Where:

H = height of water over the V-notch (ft)

3.2.3 Water Balance

The general balance between water storage, inflows, and outflows is shown in Equation 4:

$$\Delta V = V_{in} - V_{out} + P - ET - S \qquad \text{Equation 4}$$

Where:

ΔV = change in storage volume
V_{in} = inflow volume
V_{out} = outflow volume
P = precipitation
ET = evapotranspiration
S = seepage

Because the Test Cells are lined and seepage is assumed to be zero, the water balance equation can be re-arranged as shown in Equation 5:

$$V_{in} - V_{out} + P - ET - \Delta V = 0 \qquad \text{Equation 5}$$

If the net result of Equation 5 is non-zero, the residual term may be explained as the sum of the errors associated with measurements of the individual components of the water balance. As in all water balances, numerous sources of potential error exist that can affect the magnitude of the residual term. For this project, the estimates of inflow rate made using an empirical equation may be a source of error. Similarly, outflow measurement error may be tied to the use of the V-notch weir equation, but may more likely be attributable to the use of infrequent, discrete measurements that may not capture the full range of outflow variation. Potential errors associated with rainfall volumes may be attributed to spatial variation in rainfall patterns. The nearest District rain gauge is located at the ENR Outflow Pump Station, approximately 1.5 miles distant. ET data may also vary spatially. Finally, seepage losses, while unquantified, are assumed to be zero.

Exhibit 3-3 presents a monthly water balance for the period of record (February to July 1999). Inflow measurements were derived from District data as described above. Discrete outflow measurements were made approximately twice per week. Rainfall and ET data were provided by the District. ET data were not available for June and July. The average daily ET rate for May was 4.4 millimeters per day (mm/d). June and July ET rates were assigned values of 5.0 mm/d and 5.5 mm/d, respectively, as an interim estimate until actual data become available. Change in storage was estimated as the product of the cell area and the change in water level between the beginning and end of each month.

Most of the water balance residuals shown in Exhibit 3-3 are relatively small. This level of accuracy is consistent with normal expectations based on infrequent outlet stage measurements. A high negative residual for Treatment 3 in April was associated with the managed reduction in stage in response to the variable-depth requirements of the experimental design. High positive and negative residuals in May are under review, and indicate variation in one or more outflows and storage in response to a variety of factors, including rainfall and ET variation and adjustment of inflow and outflow rates.

3.3 Field Parameters

Field parameters (water temperature, pH, dissolved oxygen [DO], percent saturation, salinity, total dissolved solids [TDS], and specific conductance) were measured in the PSTA

Exhibit 3-3
Water Balances for the South Test Cells

TREATMENT	CELL	QUARTER	MONTH	INFLOW (m^3/d)	INFLOW (m^3)	OUTFLOW (m^3/d)	OUTFLOW (m^3)	RAINFALL (in)	RAINFALL (m^3)	ET (mm)	ET (m^3)	ΔSTORAGE (m^3)	RESIDUAL (m^3)	RESIDUAL (% of total inflow)
1	13	3	FEB	144.19	4037	143.64	4022	0.59	42	78	143	461	-546	-13%
		3	MAR	137.56	4264	129.11	4002	0.70	50	116	211	28	73	2%
		3	APR	144.61	4338	138.74	4162	0.71	51	129	235	28	-35	-1%
		4	MAY	144.51	4480	200.51	6216	2.09	150	137	250	-416	-1420	-31%
		4	JUN	144.86	4346	144.18	4325	12.54	902	150	273	350	299	6%
		4	JUL	144.91	4492	149.18	4625	3.18	229	171	310	11	-226	-5%
2	8	3	FEB	144.19	4037	142.03	3977	0.59	42	78	143	458	-498	-12%
		3	MAR	137.56	4264	150.30	4659	0.70	50	116	211	-69	-487	-11%
		3	APR	144.61	4338	140.47	4214	0.71	51	129	235	111	-171	-4%
		4	MAY	144.51	4480	106.75	3309	2.09	150	137	250	-94	1165	25%
		4	JUN	144.86	4346	134.30	4029	12.54	902	150	273	22	923	18%
		4	JUL	144.91	4492	136.88	4243	3.18	229	171	310	-6	173	4%
3	3	3	FEB	144.19	4037	162.01	4536	0.59	42	78	143	477	-411	-10%
		3	MAR	137.56	4264	142.82	4427	0.70	50	116	211	-67	-63	-1%
		3	APR	98.99	2970	236.35	7090	0.71	51	129	235	-189	-5031	-167%
		4	MAY	77.30	2396	58.05	1800	2.09	150	137	250	-261	502	20%
		4	JUN	144.86	4346	145.79	4374	12.54	902	150	273	727	-126	-2%
		4	JUL	144.91	4492	151.20	4687	3.18	229	171	310	-6	-271	-6%

Test Cells weekly at the inflow and outflow, and monthly at two internal sampling points (1/3 and 2/3 monitoring walkways). In addition, one recording data sonde unit, installed in the Head Cell on April 12, 1999, continuously documents inflow conditions, and two data sondes are deployed on a rotating basis at the monitoring walkways within the Test Cells.

Exhibit 3-4 summarizes the monthly averages for field parameter data during the first 6 months of operation. Appendix A provides monthly trend graphics for the key parameters measured at the Test Cells, as well as the Porta-PSTAs. A brief description of each of the field parameters is provided below.

Temperature: Average water temperatures in the Head Cell and the Test Cells increased during the study period, ranging between 17.93°C in February 1999 (Head Cell) to 31.34°C in July 1999 (Treatment 3).

pH: Consistent pH measurements were recorded during the study period with values averaging 7.63 Standard Units (SU) (June 1999) to 7.95 SU (May 1999) in the Head Cell, 7.96 SU (February 1999) to 8.99 SU (May 1999) in Treatment 1, 8.37 SU (February 1999) to 8.63 SU (June 1999) in Treatment 2, and 8.01 SU (February 1999) to 8.51 SU (May 1999) in Treatment 3.

Dissolved Oxygen: DO concentrations in the Head Cell decreased over time, with average monthly values ranging from 6.45 milligrams per liter (mg/L) in March 1999 to 2.33 mg/L in July 1999. Monthly average DO concentrations increased during the study period in Treatment 1 (8.00 mg/L in February 1999 to 11.60 mg/L in July 1999), and fluctuated in Treatment 2 (8.50 mg/L in February 1999 to 7.84 mg/L in April 1999 to 9.06 mg/L in June 1999). Treatment 3 experienced decreasing DO concentrations during the study period, with averages ranging from 8.05 mg/L (February 1999) to 6.76 mg/L (June 1999).

Conductivity: Conductivity measurements decreased during the study period in both the Head Cell and the Test Cells, with averages ranging from 1,227 micromhos per centimeter (µmhos/cm) in February 1999 (Treatment 3) to 635 µmhos/cm in June 1999 (Treatment 2).

Salinity: Salinity readings tracked the decreasing trend observed with the conductivity measurements. Average monthly values ranged from 0.79 parts per thousand (ppt) in Treatment 3 (April 1999) to 0.33 ppt in Treatment 1 (June 1999). Salinity was not recorded in the Head Cell during the study period.

Total Dissolved Solids: Monthly average TDS concentrations also decreased during the study period, with values ranging from 0.881 grams per liter (g/L) in April 1999 (Treatment 3) to 0.406 g/L in June 1999 (Treatment 1).

EXHIBIT 3-4
Monthly Averages of Field Measurements Collected from the ENR South Head Cell and the ENR PSTA Test Cells, February 1999 to July 1999

Parameter	Month	Head Cell	Treatment 1 (Peat)	Treatment 2 (Shellrock)	Treatment 3 (Shellrock -Var. Stage)
Water Temperature (°C)	February-99	17.93	17.78	19.16	18.04
	March-99	21.81	22.35	22.00	22.81
	April-99	26.44	26.44	27.38	26.34
	May-99	27.09	27.80	28.11	29.12
	June-99	27.73	28.82	28.71	28.06
	July-99	27.80	30.71	30.50	31.34
pH (units)	February-99	7.67	7.96	8.37	8.01
	March-99	7.80	8.59	8.38	8.36
	April-99	7.84	8.61	8.44	8.39
	May-99	7.95	8.99	8.55	8.51
	June-99	7.63	8.70	8.63	8.45
	July-99	7.48	8.88	8.51	8.47
Conductivity (µmhos/cm)	February-99	1219	1225	1187	1227
	March-99	1245	1260	1247	1313
	April-99	1173	1278	1309	1375
	May-99	875	905	977	929
	June-99	800	635	677	741
	July-99	824	650	733	780
Salinity (ppt)	February-99	--	--	0.62	--
	March-99	--	--	0.66	0.69
	April-99	--	0.67	0.69	0.73
	May-99	--	0.47	0.51	0.48
	June-99	--	0.33	0.35	0.38
	July-99	--	0.33	0.38	0.40
Total Dissolved Solids (g/L)	February-99	--	--	0.759	--
	March-99	--	--	0.798	0.841
	April-99	0.673	0.818	0.838	0.881
	May-99	0.560	0.730	0.752	--
	June-99	0.512	0.406	0.430	0.433
	July-99	0.529	0.480	0.527	0.499
Dissolved Oxygen Saturation (%)	February-99	--	--	92.5	--
	March-99	--	--	94.7	93.6
	April-99	62.3	120.0	99.9	96.7
	May-99	71.6	126.9	109.2	91.3
	June-99	39.8	117.0	117.1	87.0
	July-99	29.7	153.6	118.3	102.7
Dissolved Oxygen (mg/L)	February-99	5.97	8.00	8.50	8.05
	March-99	6.45	9.19	8.21	7.99
	April-99	4.98	9.59	7.84	7.72
	May-99	5.69	9.98	8.50	6.97
	June-99	3.12	8.98	9.06	6.76
	July-99	2.33	11.60	8.82	7.56

3.4 Water Quality Data

Water quality samples were collected at the Head Cell and at different locations within each Test Cell at varying frequencies in accordance with the PSTA Research Plan. Phosphorus samples were collected at the highest frequency and were analyzed for a number of phosphorus forms. Head Cell samples (representing Test Cell inflows) and Test Cell outflow samples were collected weekly for analysis of total phosphorus (TP), total dissolved phosphorus (TDP), and dissolved reactive phosphorus (DRP). Individual cell inflows were monitored monthly, and internal stations were sampled quarterly for these parameters. From the collected phosphorus data, total particulate phosphorus (TPP) is estimated by the difference: TP - TDP, and dissolved organic phosphorus (DOP) is estimated by the difference: TDP - DRP.

Monthly and quarterly water quality samples were analyzed for total nitrogen (TN), major nitrogen (N) forms (total Kjeldahl N [TKN], total ammonia N [NH_3-N], and nitrate + nitrite N [NOx-N]), calcium, total suspended solids (TSS), alkalinity, and total organic carbon (TOC). Parameters were sampled monthly at the Head Cell and at the outflows of the three PSTA Test Cells; Test Cell inflow points and the internal stations were sampled quarterly for these parameters. From the collected nitrogen data, organic nitrogen is estimated by the difference: TKN - NH_3-N.

Monthly average values for water quality data collected from February 1999 to July 1999 at the Head Cell and the three Test Cells are presented in Exhibit 3-5, and are summarized below. Appendix A provides monthly trend graphics for the key parameters measured at the Test Cells, as well as the Porta-PSTAs.

Total Phosphorus: TP levels initially increased as water passed through each Test Cell because of increased levels of TPP during the startup period of February from April 1999. This finding is believed to be related to re-suspension of loosely consolidated sediments and export because of wind mixing following startup and prior to significant periphyton and macrophyte establishment.

For the study period from May from July 1999, eight out of nine monthly average outflow TP concentrations were less than corresponding inflow concentrations. Monthly average inflow TP concentrations for this period ranged from 0.018 mg/L to 0.026 mg/L for the three treatments. Average outflow TP concentrations decreased to 0.013 mg/L (Treatment 1), 0.014 mg/L (Treatment 2), and 0.017 mg/L (Treatment 3) in July.

Detailed TP trend charts are provided in Exhibits 3-6 through 3-8 and in Appendix A.

Total Nitrogen: TN levels in all three treatments decreased as water passed through each cell. In general, monthly inflow TN concentration decreased during the study period, with values ranging from 2.27 mg/L in February 1999 (Treatment 1) to 0.66 mg/L in July 1999 (Treatment 1). Monthly outflow TN concentration followed a similar pattern with values ranging from 1.74 mg/L in February 1999 (Treatment 1) to 0.44 mg/L in July 1999 (Treatment 1).

Exhibit 3-5

Monthly Average Values of Water Quality Data Collected at the
ENR South Head Cell and ENR PSTA Test Cells, February 1999 to July 1999

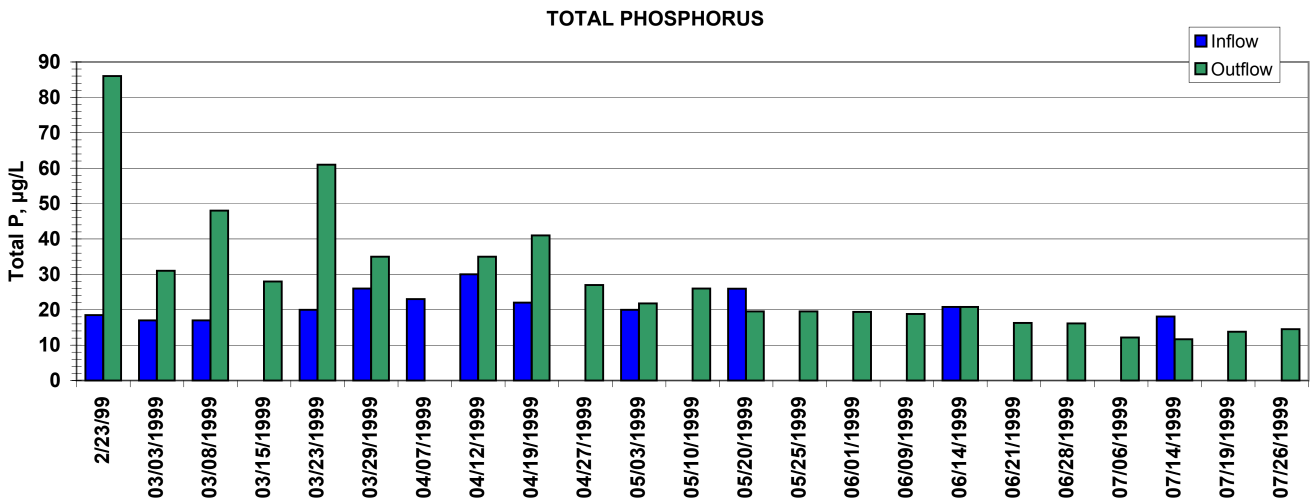
Parameter	Month	Treatment 1 (Peat) Inflow	Treatment 1 (Peat) Outflow	Treatment 2 (Shellrock) Inflow	Treatment 2 (Shellrock) Outflow	Treatment 3 (Shellrock-Variable Stage) Inflow	Treatment 3 (Shellrock-Variable Stage) Outflow
Total Phosphorus, as P (mg/L)	February-99	0.019	0.086	0.021	0.025	0.019	0.035
	March-99	0.020	0.041	0.021	0.028	0.020	0.038
	April-99	0.025	0.035	0.025	0.031	0.026	0.037
	May-99	0.023	0.022	0.023	0.021	0.023	0.026
	June-99	0.021	0.018	0.022	0.020	0.026	0.025
	July-99	0.018	0.013	0.018	0.014	0.018	0.017
Total Particulate Phosphorus (mg/L)	February-99	0.010	0.070	0.014	0.000	0.011	0.024
	March-99	0.010	0.029	0.011	0.016	0.010	0.027
	April-99	0.015	0.018	0.015	0.016	0.012	0.020
	May-99	0.006	0.004	0.001	0.004	0.006	0.009
	June-99	0.006	0.007	0.008	0.010	0.014	0.014
	July-99	0.006	0.005	0.006	0.001	0.008	0.009
Total Dissolved Phosphorus (mg/L)	February-99	0.009	0.016	0.008	0.025	0.008	0.011
	March-99	0.010	0.011	0.010	0.013	0.010	0.011
	April-99	0.014	0.016	0.014	0.016	0.016	0.017
	May-99	0.017	0.017	0.022	0.017	0.016	0.017
	June-99	0.014	0.011	0.014	0.010	0.013	0.010
	July-99	0.013	0.008	0.012	0.013	0.010	0.008
Soluble Reactive Phosphorus (mg/L)	February-99	0.009	0.005	0.006	0.003	0.004	0.002
	March-99	0.006	0.005	0.005	0.006	0.007	0.003
	April-99	0.006	0.004	0.005	0.003	0.007	0.004
	May-99	0.011	0.007	0.011	0.006	0.010	0.008
	June-99	0.006	0.002	0.005	0.002	0.003	0.002
	July-99	0.006	0.002	0.004	0.003	0.004	0.002
Dissolved Organic Phosphorus (mg/L)	February-99	0.000	0.011	0.002	0.022	0.003	0.009
	March-99	0.005	0.006	0.006	0.007	0.004	0.008
	April-99	0.009	0.012	0.010	0.013	0.010	0.014
	May-99	0.004	0.011	0.008	0.011	0.005	0.009
	June-99	0.009	0.009	0.009	0.007	0.009	0.008
	July-99	0.006	0.006	0.007	0.010	0.006	0.006
Total Nitrogen, as N (mg/L)	February-99	2.27	1.74	2.25	0.98	2.22	1.43
	March-99	2.16	0.63	1.85	1.10	1.98	0.67
	April-99	1.90	0.95	1.76	0.86	1.80	1.09
	May-99	1.47	1.16	1.39	1.38	2.58	1.28
	June-99	0.96	0.84	0.96	1.00	0.96	0.93
	July-99	0.66	0.44	0.70	0.65	0.78	0.57
Total Kjeldahl Nitrogen, as N (mg/L)	February-99	2.10	1.66	2.10	0.98	2.10	1.43
	March-99	1.99	0.63	1.68	1.50	1.83	0.67
	April-99	1.83	0.95	1.68	1.06	1.73	1.10
	May-99	1.42	1.16	1.37	1.38	2.56	1.28
	June-99	0.96	0.84	0.96	1.00	0.96	0.93
	July-99	0.61	0.44	0.65	0.65	0.78	0.57
Nitrate/Nitrite, as N (mg/L)	February-99	0.17	0.08	0.15	0.03	0.12	0.03
	March-99	0.17	0.03	0.18	0.01	0.15	0.02
	April-99	0.08	0.03	0.09	0.02	0.08	0.02
	May-99	0.05	0.03	0.03	0.03	0.03	0.03
	June-99	0.03	0.03	0.03	0.03	0.03	0.03
	July-99	0.05	0.03	0.05	0.03	0.03	0.03
Ammonia, as NH_3 (mg/L)	February-99	0.15	<0.04	0.15	<0.04	0.15	<0.04
	March-99	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
	April-99	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
	May-99	0.06	0.05	0.07	0.05	0.05	0.05
	June-99	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
	July-99	0.06	<0.04	0.05	<0.04	<0.04	<0.04

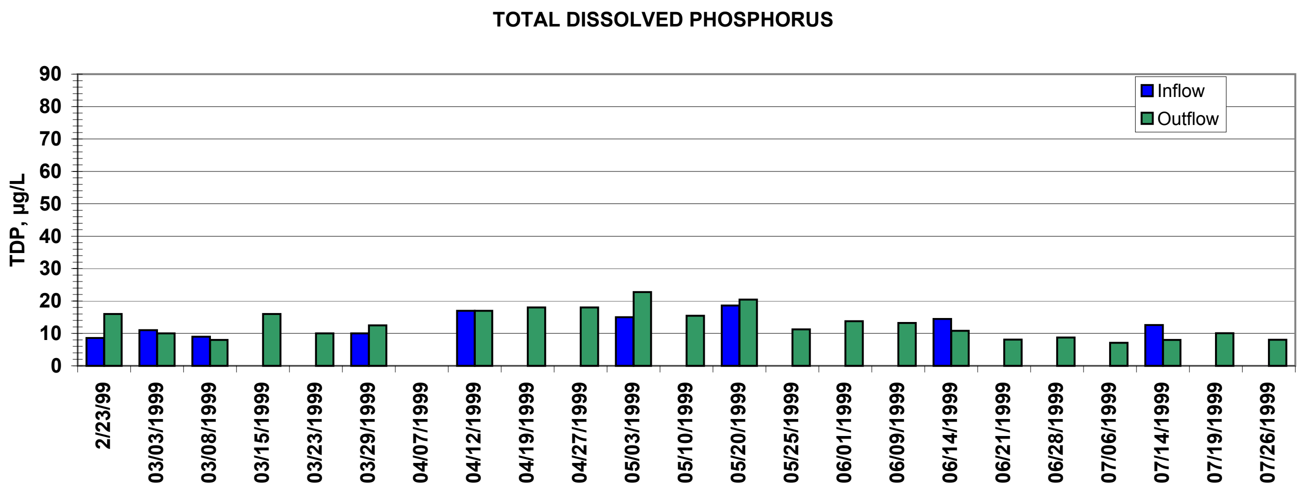
Exhibit 3-5

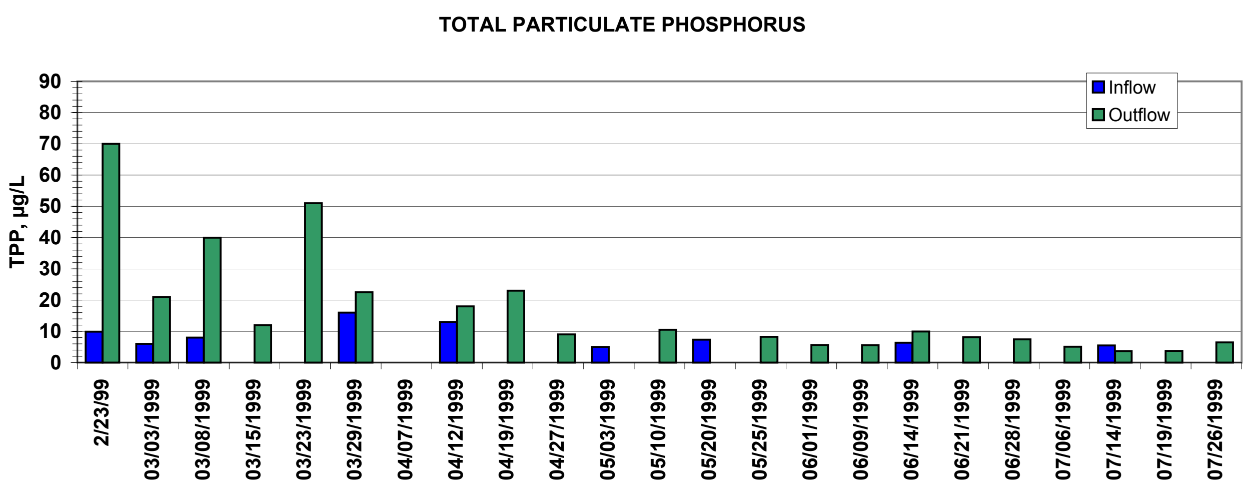
Monthly Average Values of Water Quality Data Collected at the
ENR South Head Cell and ENR PSTA Test Cells, February 1999 to July 1999

		Treatment					
		1 (Peat)		2 (Shellrock)		3 (Shellrock-Variable Stage)	
Parameter	**Month**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**
Organic Nitrogen (mg/L)	February-99	1.95	1.64	1.95	0.96	1.95	1.41
	March-99	1.68	0.61	0.70	1.48	1.13	0.65
	April-99	1.56	0.93	1.07	1.04	1.29	1.08
	May-99	1.11	1.11	1.18	1.33	3.50	1.23
	June-99	0.94	0.82	0.94	0.98	0.94	0.91
	July-99	0.55	0.42	0.59	0.63	0.76	0.55
TOC (mg/L)	February-99	31.00	32.70	31.00	32.50	31.00	33.00
	March-99	37.43	35.60	37.89	35.27	37.48	35.38
	April-99	39.45	38.50	38.95	37.74	38.80	37.64
	May-99	27.90	29.40	27.80	32.10	27.70	30.70
	June-99	24.00	20.70	24.00	23.20	24.00	21.50
	July-99	30.00	26.40	31.00	29.00	29.80	26.90
TSS (mg/L)	February-99	4.0	<4.0	4.7	<4.0	4.5	<4.0
	March-99	1.7	6.0	<4.0	4.8	<4.0	<4.0
	April-99	4.8	9.0	4.8	3.4	4.8	7.1
	May-99	2.8	4.0	<4.0	<4.0	<4.0	10.0
	June-99	4.0	<4.0	4.0	<4.0	4.0	26.0
	July-99	<4.0	<4.0	8.0	<4.0	<4.0	<4.0
Calcium (mg/L)	February-99	76.00	70.90	76.00	72.00	77.00	77.70
	March-99	70.67	49.20	70.77	66.05	71.30	71.20
	April-99	56.85	45.50	56.93	56.03	57.73	63.20
	May-99	45.96	15.70	46.30	32.20	46.13	34.10
	June-99	45.00	22.00	45.00	30.00	45.00	30.00
	July-99	55.80	23.00	56.00	40.60	55.80	37.90
Alkalinity (mg/L)	February-99	290.0	278.0	290.0	276.0	290.0	276.0
	March-99	304.4	258.0	303.7	278.4	304.3	283.2
	April-99	230.7	240.5	231.0	262.7	231.8	271.6
	May-99	178.3	105.0	179.5	161.0	182.1	163.0
	June-99	173.0	104.0	173.0	125.0	173.0	114.0
	July-99	226.0	126.0	233.0	183.0	167.0	230.0

Notes:
For values reported as below the method detection limit, one-half the method detection limit was used in the calculation of average values.

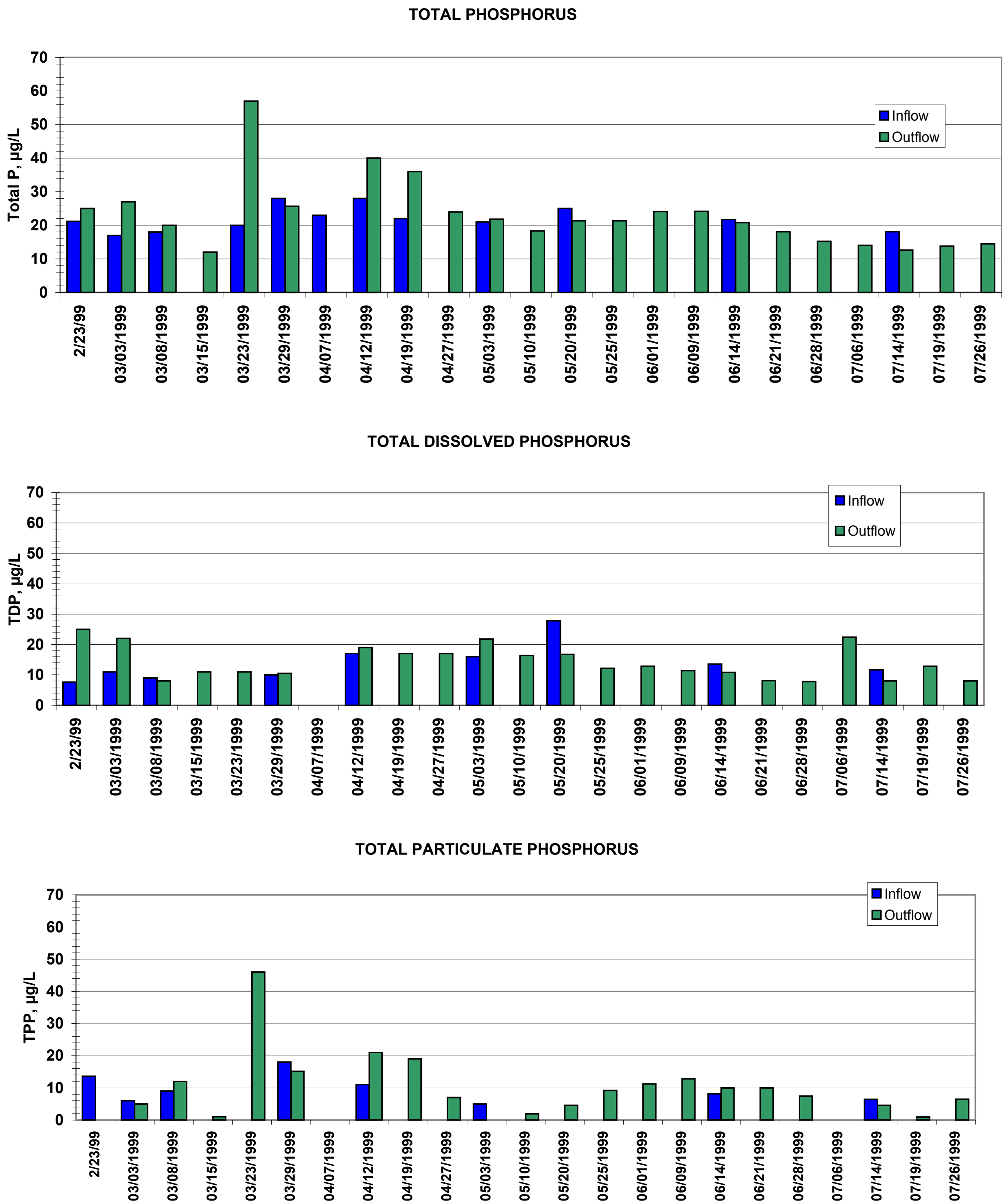






Note: Inflow TP and TDP data are collected by the District; missing data points are either not available or pending.

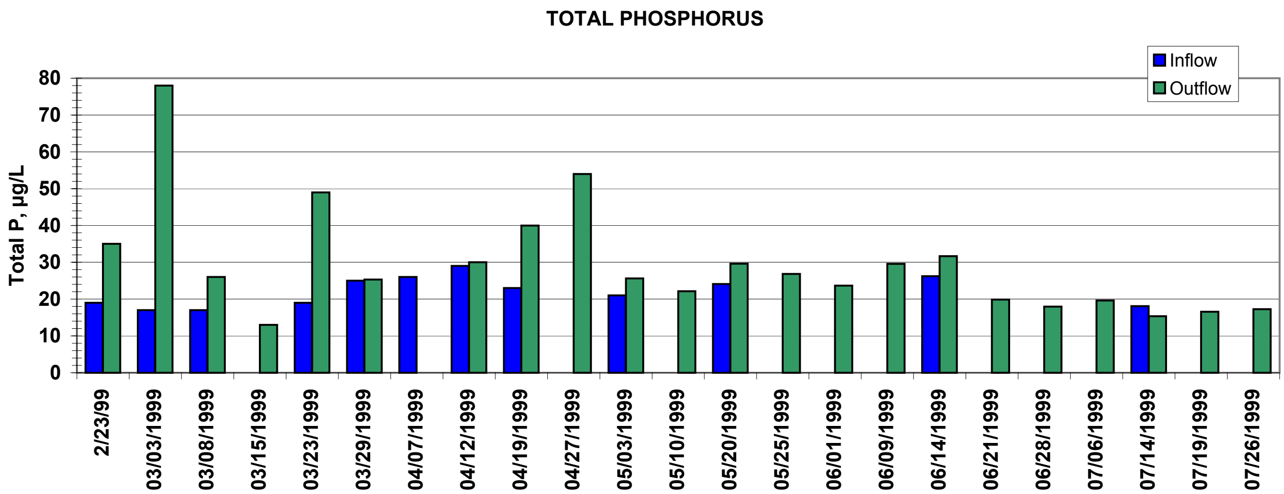
Exhibit 3-6
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for South Test Cell Treatment No. 1, February - July 1999

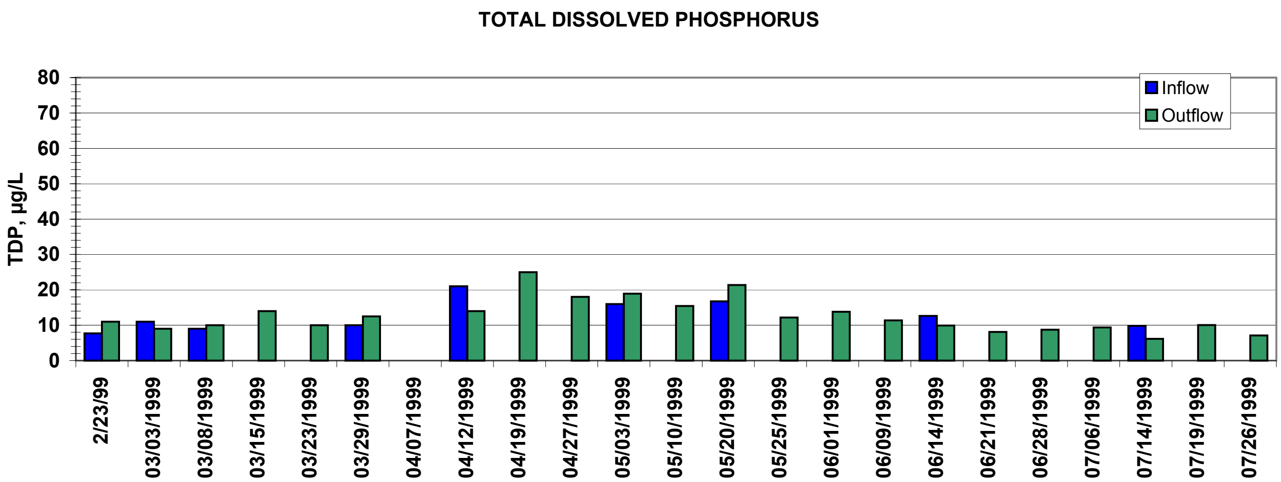


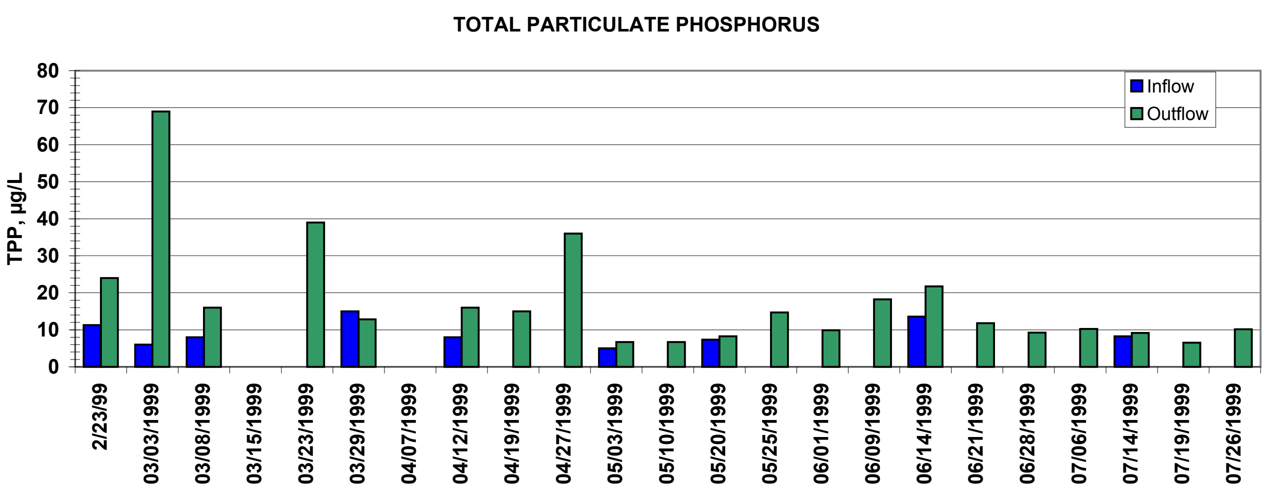
Note: Inflow TP and TDP data are collected by the District; missing data points are either not available or pending.

Exhibit 3-7

Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for South Test Cell Treatment No. 2, February - July 1999







Note: Inflow TP and TDP data are collected by the District; missing data points are either not available or pending.

Exhibit 3-8

Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for South Test Cell Treatment No. 3, February - July 1999

Calcium: Calcium concentrations decreased during the study period in the inflow to the Test Cells, with averages ranging from 77 mg/L for Treatment 3 in February 1999 to 55.80 mg/L in July 1999 at Treatments 1 and 3. In general, outflow calcium concentrations were less than inflow concentrations; monthly averages for the outflows ranged from 77.70 for Treatment 3 (February 1999) to 15.70 mg/L for Treatment 1 (May 1999).

Alkalinity: Inflow and outflow alkalinity concentrations decreased during the study period. Inflow concentrations ranged from 304.4 mg/L in March 1999 (Treatment 1) to 173.0 mg/L in June 1999 for all treatments. The majority of outflow alkalinity concentrations were lower than corresponding inflow measurements, with averages ranging from 278 mg/L in February 1999 (Treatment 1) to 104 mg/L in June 1999 (Treatment 1).

Total Suspended Solids: TSS inflow concentrations ranged from below the detection limit (BDL) of 4.0 mg/L for several months to 4.8 mg/L in April 1999 (Treatments 1 and 3). The highest outflow TSS concentrations were recorded in Treatment 3 (10.0 mg/L in May 1999 and 26.0 mg/L in June 1999). All other TSS outflow concentrations ranged from BDL to 9.0 mg/L in April 1999 at Treatment 1. TSS detection was reduced to 2.0 mg/L in August 1999 and to 1.0 mg/L in September 1999.

Total Organic Carbon: TOC inflow concentrations ranged from 39.45 mg/L at Treatment 1 in April 1999 to 24 mg/L in June 1999 at all three treatments. Outflow TOC concentrations were lower than corresponding inflow concentrations in March 1999, April 1999, June 1999, and July 1999 but higher in February 1999 and May 1999. Outflow concentrations ranged from 38.50 mg/L in April 1999 (Treatment 1) to 20.70 mg/L in June 1999 (Treatment 1).

3.5 Mass Balances

Nutrient removal performance is most meaningfully quantified by a mass balance comparing the total loads entering and leaving the system. Phosphorus removal through biological or chemical processes or export can be estimated simply as the difference between these loads. As a preliminary assessment of PSTA performance, inflow and outflow mass balances were estimated for each of the ENR Test Cells using the inflow and outflow concentration and HLR data presented in Section 3.2. Mean treatment inflow and outflow loads were used to calculate mean treatment removal rates for TP, TPP, TDP, and TN. First-order TP rate constants were calculated from the monthly data for three values of C*: 0.001 mg/L, 0.005 mg/L, and 0.010 mg/L. Contributions of rainfall to phosphorus and nitrogen loads to the Test Cells were not included in these mass loading estimates. Preliminary estimates indicate that rainfall load may make up between 1 to 10 percent of the total load. Final mass balance analyses for this project will include estimates of rainfall loads of TP and TN derived from available data.

To facilitate assessment of experimental treatment effects on system phosphorus removal performance, Exhibit 3-9 provides quarterly descriptive statistics for inflow and outflow hydraulic loading and phosphorus parameters. Exhibit 3-10 provides monthly treatment

Exhibit 3-9
ENR Test Cell Mass Balance Phosphorus Data Summarized by Project Quarter

Treatment	Cell	Quarter	Summary Statistics	Inflow (m^3/d)	Outflow (m^3/d)	Avg_flow (m^3/d)	q_in (cm/d)	q_out (cm/d)	q_avg (cm/d)	TP (mg/L) Inflow	TP (mg/L) Outflow	TP ($g/m^2/y$) Inflow	TP ($g/m^2/y$) Outflow	TP ($g/m^2/y$) Removed	TP ($g/m^2/y$) %Removal
1	13	Qtr-3	Mean	138.46	134.95	136.70	5.25	5.12	5.19	0.022	0.044	0.42	0.72	-0.30	-72%
			Stdev	12.23	22.96	14.39	0.47	0.87	0.55	0.005	0.011	0.10	0.24		
			Max	144.70	169.16	156.84	5.50	6.41	5.94	0.030	0.061	0.60	1.08		
			Min	111.31	94.85	119.71	4.22	3.59	4.53	0.017	0.027	0.31	0.35		
			N	9	9	9	9	9	9	7	8	7	8		
1	13	Qtr-4	Mean	144.67	151.20	147.94	5.51	5.75	5.63	0.021	0.018	0.43	0.39	0.03	8%
			Stdev	0.18	45.19	22.57	0.08	1.69	0.83	0.003	0.019	0.06	0.17		
			Max	144.91	203.52	174.05	5.69	7.61	6.52	0.026	0.021	0.51	0.71		
			Min	144.43	43.81	94.19	5.39	1.68	3.62	0.018	0.012	0.36	0.12		
			N	11	11	11	11	11	11	5	13	4	11		
2	8	Qtr-3	Mean	138.46	145.01	141.74	5.27	5.52	5.39	0.022	0.030	0.42	0.60	-0.18	-42%
			Stdev	12.23	17.69	9.88	0.46	0.67	0.37	0.004	0.014	0.09	0.28		
			Max	144.70	174.09	159.33	5.51	6.58	6.02	0.028	0.057	0.56	1.19		
			Min	111.31	108.54	126.53	4.24	4.11	4.79	0.017	0.012	0.31	0.26		
			N	9	9	9	9	9	9	7.000	8	7	8		
2	8	Qtr-4	Mean	144.67	135.89	140.28	5.54	5.20	5.37	0.021	0.018	0.44	0.36	0.08	17%
			Stdev	0.18	34.18	17.10	0.07	1.31	0.65	0.003	0.004	0.06	0.12		
			Max	144.91	176.78	160.60	5.67	6.72	6.10	0.025	0.024	0.52	0.59		
			Min	144.43	71.02	107.79	5.47	2.71	4.11	0.018	0.013	0.36	0.23		
			N	11	11	11	11	11	11	4	13	4	11		
3	3	Qtr-3	Mean	118.19	190.46	154.32	4.47	7.27	5.87	0.022	0.039	0.36	1.19	-0.83	-227%
			Stdev	28.74	112.40	49.04	1.05	4.46	1.97	0.005	0.021	0.09	1.14		
			Max	144.65	488.45	282.89	5.49	19.10	11.06	0.029	0.078	0.52	3.77		
			Min	77.31	129.58	124.12	2.99	4.88	4.80	0.017	0.013	0.25	0.26		
			N	9	9	9	9	9	9	7	8	7	8		
3	3	Qtr-4	Mean	116.73	118.27	117.50	4.41	4.47	4.44	0.022	0.023	0.34	0.39	-0.05	-14%
			Stdev	33.24	48.91	37.23	1.05	1.78	1.24	0.004	0.006	0.12	0.19		
			Max	144.91	162.01	153.22	5.34	6.67	5.66	0.026	0.032	0.50	0.67		
			Min	77.26	38.62	57.94	3.12	1.55	2.35	0.018	0.015	0.24	0.13		
			N	11	11	11	11	11	11	4	13	4	11		

Exhibit 3-9
ENR Test Cell Mass Balance Phosphorus Data Summarized by Project Quarter

Treatment	Cell	Quarter	Summary Statistics	TPP (mg/L)		TPP (g/m²/y)				TDP (mg/L)		TDP (g/m²/y)			
				Inflow	Outflow	Inflow	Outflow	Removed	%Removal	Inflow	Outflow	Inflow	Outflow	Removed	%Removal
1	13	Qtr-3	Mean	0.011	0.025	0.20	0.46	-0.26	-127%	0.012	0.014	0.23	0.26	-0.03	-14%
			Stdev	0.005	0.014	0.08	0.25			0.004	0.004	0.08	0.10		
			Max	0.016	0.051	0.27	0.91			0.017	0.018	0.34	0.42		
			Min	0.006	0.009	0.12	0.12			0.009	0.008	0.17	0.14		
			N	4	8	4	8			4	8	4	8		
1	13	Qtr-4	Mean	0.007	0.010	0.12	0.12	0.00	-1%	0.014	0.012	0.31	0.27	0.03	11%
			Stdev	0.002	0.018	0.02	0.10			0.004	0.005	0.05	0.15		
			Max	0.010	0.070	0.14	0.29			0.019	0.023	0.37	0.50		
			Min	0.005	-0.001	0.10	-0.02			0.009	0.007	0.25	0.08		
			N	5	14	4	11			5	14	4	11		
2	8	Qtr-3	Mean	0.011	0.016	0.21	0.31	-0.10	-50%	0.012	0.014	0.23	0.29	-0.06	-26%
			Stdev	0.005	0.014	0.08	0.29			0.004	0.005	0.08	0.10		
			Max	0.018	0.046	0.31	0.96			0.017	0.022	0.34	0.43		
			Min	0.006	0.001	0.12	0.02			0.009	0.008	0.17	0.16		
			N	4	8	4	8			4	8	4	8		
2	8	Qtr-4	Mean	0.004	0.005	0.08	0.10	-0.02	-21%	0.017	0.013	0.35	0.26	0.09	26%
			Stdev	0.005	0.006	0.10	0.13			0.007	0.005	0.15	0.13		
			Max	0.008	0.013	0.16	0.31			0.028	0.022	0.57	0.49		
			Min	-0.003	-0.008	-0.06	-0.19			0.012	0.008	0.24	0.13		
			N	4	13	4	11			4	13	4	11		
3	3	Qtr-3	Mean	0.009	0.025	0.16	0.78	-0.61	-383%	0.013	0.014	0.21	0.42	-0.20	-95%
			Stdev	0.004	0.022	0.07	0.85			0.006	0.005	0.05	0.36		
			Max	0.015	0.069	0.25	2.51			0.021	0.025	0.28	1.26		
			Min	0.006	-0.001	0.11	-0.02			0.009	0.009	0.17	0.20		
			N	4	8	4	8			4	8	4	8		
3	3	Qtr-4	Mean	0.009	0.011	0.14	0.20	-0.06	-40%	0.014	0.012	0.20	0.19	0.01	5%
			Stdev	0.004	0.005	0.09	0.13			0.003	0.005	0.03	0.11		
			Max	0.014	0.022	0.26	0.46			0.017	0.021	0.24	0.46		
			Min	0.005	0.007	0.06	0.04			0.010	0.006	0.19	0.08		
			N	4	13	4	11			4	13	4	11		

Exhibit 3-9
ENR Test Cell Mass Balance Phosphorus Data Summarized by Project Quarter

Treatment	Cell	Quarter	Summary Statistics	SRP (mg/L)		SRP (g/m2/y)				DOP (mg/L)		DOP (g/m2/y)			
				Inflow	Outflow	Inflow	Outflow	Removed	%Removal	Inflow	Outflow	Inflow	Outflow	Removed	%Removal
1	13	Qtr-3	Mean	0.006	0.004	0.11	0.08	0.03	25%	0.008	0.009	0.15	0.18	-0.03	-22%
			Stdev	0.003	0.002	0.05	0.04			0.005	0.004	0.10	0.10		
			Max	0.010	0.008	0.20	0.16			0.014	0.015	0.28	0.35		
			Min	0.003	0.003	0.06	0.05			0.004	0.005	0.07	0.09		
			N	7	8	7	8			4	8	4	8		
1	13	Qtr-4	Mean	0.009	0.003	0.18	0.08	0.09	52%	0.004	0.009	0.11	0.19	-0.07	-63%
			Stdev	0.005	0.004	0.11	0.11			0.004	0.004	0.08	0.11		
			Max	0.019	0.017	0.37	0.41			0.009	0.018	0.18	0.37		
			Min	0.006	0.000	0.11	0.00			0.000	0.003	-0.01	0.07		
			N	6	14	5	11			5	14	4	11		
2	8	Qtr-3	Mean	0.005	0.005	0.10	0.09	0.01	6%	0.008	0.010	0.15	0.20	-0.04	-29%
			Stdev	0.002	0.005	0.03	0.09			0.005	0.005	0.09	0.10		
			Max	0.008	0.016	0.14	0.32			0.014	0.016	0.28	0.36		
			Min	0.003	0.002	0.06	0.03			0.004	0.005	0.08	0.09		
			N	7	8	7	8			4	8	4	8		
2	8	Qtr-4	Mean	0.009	0.004	0.17	0.09	0.09	51%	0.008	0.009	0.16	0.19	-0.02	-13%
			Stdev	0.005	0.004	0.10	0.10			0.004	0.005	0.09	0.13		
			Max	0.015	0.017	0.30	0.38			0.013	0.019	0.27	0.42		
			Min	0.004	0.001	0.09	0.01			0.003	0.000	0.06	0.00		
			N	5	12	5	10			4	12	4	10		
3	3	Qtr-3	Mean	0.007	0.003	0.11	0.09	0.02	22%	0.007	0.011	0.11	0.33	-0.22	-188%
			Stdev	0.003	0.001	0.05	0.03			0.008	0.005	0.11	0.34		
			Max	0.009	0.005	0.16	0.14			0.018	0.020	0.24	1.12		
			Min	0.003	0.002	0.04	0.04			0.001	0.006	0.02	0.13		
			N	7	8	7	8			4	8	4	8		
3	3	Qtr-4	Mean	0.007	0.004	0.10	0.06	0.03	32%	0.006	0.008	0.10	0.13	-0.02	-24%
			Stdev	0.004	0.006	0.04	0.08			0.003	0.004	0.06	0.10		
			Max	0.014	0.023	0.16	0.30			0.009	0.016	0.18	0.39		
			Min	0.003	0.001	0.07	0.00			0.003	-0.002	0.03	-0.02		
			N	5	13	5	11			4	13	4	11		

Exhibit 3-10

ENR Test Cell Mass Balance Phosphorus Data Summarized by Month

Treatment	Cell	Month	TP (mg/L)		Inflow	Outflow	Avg_flow	q_in	q_out	q_avg	MB_TP ($g/m^2/y$)		Removal			Calc_k		
			Inflow	Outflow	(m^3/d)	(m^3/d)	(m^3/d)	(cm/d)	(cm/d)	(cm/d)	Inflow	Outflow	($g/m^2/y$)	(%)	C*=	0.001	0.005	0.010
	13	Feb-1999	0.019	0.086	144.19	143.64	143.91	5.50	5.48	5.49	0.371	1.720	-1.349	-363.09		-31.67	-35.90	-43.90
1	13	Mar-1999	0.020	0.041	133.63	128.80	131.22	5.07	4.88	4.97	0.385	0.720	-0.334	-86.84		-13.33	-15.69	-20.31
1	13	Apr-1999	0.025	0.035	144.59	139.59	142.09	5.52	5.33	5.42	0.504	0.632	-0.128	-25.35		-6.39	-7.45	-9.38
1	13	May-1999	0.023	0.022	144.54	155.72	150.13	5.47	5.87	5.67	0.457	0.473	-0.016	-3.41		1.23	1.51	2.13
1	13	Jun-1999	0.021	0.018	144.75	149.64	147.19	5.51	5.70	5.61	0.419	0.384	0.035	8.44		2.78	3.55	5.44
1	13	Jul-1999	0.018	0.013	144.91	149.18	147.05	5.50	5.66	5.58	0.361	0.252	0.109	30.29		7.16	9.97	20.03
2	8	Feb-1999	0.021	0.025	144.19	142.03	143.11	5.50	5.42	5.46	0.425	0.494	-0.069	-16.16		-3.43	-4.20	-5.82
2	8	Mar-1999	0.021	0.028	133.63	148.65	141.14	5.10	5.67	5.38	0.403	0.585	-0.183	-45.39		-6.38	-7.72	-10.49
2	8	Apr-1999	0.025	0.031	144.59	139.77	142.18	5.52	5.34	5.43	0.505	0.610	-0.105	-20.80		-4.49	-5.27	-6.73
2	8	May-1999	0.023	0.021	144.54	110.77	127.66	5.55	4.26	4.90	0.463	0.317	0.146	31.61		1.98	2.45	3.49
2	8	Jun-1999	0.022	0.020	144.75	155.57	150.16	5.51	5.92	5.71	0.437	0.447	-0.010	-2.17		1.28	1.60	2.32
2	8	Jul-1999	0.018	0.014	144.91	136.88	140.89	5.52	5.21	5.37	0.363	0.267	0.096	26.35		5.79	7.96	15.22
3	3	Feb-1999	0.019	0.035	144.19	162.01	153.10	5.49	6.17	5.83	0.381	0.788	-0.407	-106.98		-13.53	-16.21	-21.73
3	3	Mar-1999	0.020	0.038	133.63	147.25	140.44	5.01	5.52	5.26	0.373	0.769	-0.396	-106.30		-13.45	-15.95	-20.95
3	3	Apr-1999	0.026	0.037	94.65	221.48	158.07	3.67	8.65	6.16	0.355	1.320	-0.965	-272.15		-8.63	-9.97	-12.39
3	3	May-1999	0.023	0.026	84.52	60.89	72.70	3.41	2.46	2.93	0.258	0.232	0.026	10.04		-1.62	-1.95	-2.64
3	3	Jun-1999	0.026	0.025	144.75	148.84	146.80	5.28	5.43	5.36	0.505	0.490	0.016	3.12		1.34	1.60	2.13
3	3	Jul-1999	0.018	0.017	144.91	151.20	148.05	5.28	5.51	5.40	0.347	0.395	-0.048	-13.86		1.07	1.41	2.33

means for inflow and outflow total phosphorus parameters to provide a means of summarizing seasonal changes in system performance.

3.5.1 Phosphorus

The revised Research Plan identified an average experimental HLR of 6 cm/d to all Test Cells, with Cell 3 (Treatment 3) receiving a variable load over a variable depth during operations while depths in Cells 8 and 13 (Treatments 2 and 1, respectively) are held constant (CH2M HILL, 1999). Assuming an average influent concentration of 0.040 mg/L, the calculated TP mass loads were expected to average 0.88 $g/m^2/y$ for all treatments but Treatment 3 would be expected to see greater monthly variation in loads.

As shown in Exhibit 3-2, the HLRs were near the target loading rate and averaged between 4.5 to 5.5 cm/d. However, because of the lower than expected TP concentrations in the ENR source waters, monthly TP mass loadings have averaged significantly lower than expected for the project duration, ranging from a maximum of 0.50 $g/m^2/y$ to a minimum of 0.26 $g/m^2/y$ in July (Exhibit 3-10). Inflow concentrations of TP from the ENR averaged 0.021 mg/L during the third and fourth quarters, generally decreasing to 0.018 mg/L in July.

Discussion of the results of this mass balance analysis in this 4th Quarterly Report should be considered preliminary and subject to revision, given the initial stages of algal community development within the Test Cell mesocosms. During the fourth quarter, average inflow TP mass loadings for Treatments 1, 2, and 3 were 0.43, 0.44, and 0.34 $g/m^2/y$, respectively. Corresponding outflow mass loadings were 0.39, 0.36, and 0.39 $g/m^2/y$, respectively. Mass removals for TP were 8, 17, and -14 percent, respectively. Average outflow TP concentrations for the Test Cells ranged from 0.018 to 0.023 mg/L. Preliminary analysis of means between all treatments (Exhibit 3-9) indicated that the treatment means within this range are not anticipated to be statistically significantly different. Within- and between-treatment variance, as well as experimental effects such as system age, will be fully quantified by analysis of variance (ANOVA) within future reports when sufficient data are available for cost-effective analysis.

Average inflow TPP mass loadings for all treatments ranged from 0.08 to 0.14 $g/m^2/y$. Outflow TPP mass loadings ranged from 0.10 to 0.20 $g/m^2/y$. All treatments exported TPP.

The quarterly summary assessment described above obscures important seasonal trends in PSTA performance, as quantified by the first-order areal rate constant. Average TP rate constants were calculated from monthly mean concentration data and average HLRs using the k-C* model. For this analysis, three C* scenarios were assumed with concentrations of 0.001, 0.005, and 0.010 mg/L.

The k-C* model equation, arranged to solve for the removal rate (k) is:

$$k = -q_{avg} \ln\left(\frac{C_{out} - C^*}{C_{in} - C^*} \right)$$

Where:

k = area-based rate constant (m/y)

q_{avg} = average hydraulic loading rate (m/y)
C_{out} = outflow concentration (mg/L)
C_{in} = inflow concentration (mg/L)

Average monthly k values have consistently increased for all treatments since startup. Initial values were negative while k values for June and July were all positive. Negative TP removals early in the project are indicative of a release of TP from the sediments. Calculated k values are the net result of internal TP gains and losses. A continuing loss of TP from sediments is considered likely and may be resulting in relatively low net k values despite high levels of plant development and TP trapping in new biomass and accreted sediments (see Exhibit 3-10, and Appendix A). Monthly average rate constants ranged upward to 20 m/y in July, depending upon the C* selected.

3.5.2 Nitrogen

For the fourth quarter, average inflow TN mass loadings for Treatments 1, 2, and 3 were 26.0, 25.0, and 25.8 $g/m^2/y$, respectively. Outflow mass loadings were 24.6, 16.9, 16.3 $g/m^2/y$, respectively. Mass removals for TN were 6, 32, and 37 percent, respectively. Exhibit 3-11 presents a summary of nitrogen mass balances by treatment for TN, total Kjeldahl nitrogen (TKN), $NO_{2/3}$, NH_3, and organic nitrogen for the fourth quarter.

3.6 Sediments

Pre-existing and newly deposited soils within the PSTA Test Cells (ENR South Test Cell Site) were cored at randomly selected locations along each of the internal monitoring boardwalks and analyzed separately from the depth increment 0–10 cm. Exhibit 3-12 summarizes monthly sediment data from the PSTA Test Cells during the third and fourth quarters. Subsamples from each of the cores were analyzed, and key parameter analyses are highlighted as follows.

Bulk Density: Sediment samples were collected monthly from internal stations and analyzed for density and percent solids. Bulk density is estimated in these samples by multiplying the sample's wet density by the percent solids.

The peat soils in Treatment 1 (Test Cell 13) are highly organic and exhibit low bulk densities, which average 0.45 g/cm^3, as compared to the shell rock soils of Treatments 2 and 3 (Test Cell 8 and 3), which average 1.41 g/cm^3. Bulk densities have increased in these PSTA Test Cells on average between 12 and 62 percent during the period from February through July 1999.

Phosphorus: Sediment samples were collected monthly from the PSTA Test Cell internal monitoring stations and analyzed monthly for TP and total inorganic phosphorus (TIP), and quarterly for non-reactive phosphorus (NRP).

NRP analyses for sediment samples collected during the fourth quarter are not yet available, and will be incorporated into the next quarterly report. In Treatment 1 (Test Cell 13), the average TP concentration varied between 286.3 and 467.7 milligrams per kilogram (mg/kg) with an average TIP concentration between 227.7 and 454.0 mg/kg. TP and TIP were at their greatest concentrations during the initial sampling event (February 1999) and declined in the succeeding samples. The TP

Exhibit 3-11
ENR Test Cell Mass Balance Nitrogen Data Summarized by Project Quarter

Treatment	Cell	Time-Period	Stats	Inflow (m^3/d)	Outflow (m^3/d)	Avg_flow (m^3/d)	q_in (cm/d)	q_out (cm/d)	q_avg (cm/d)	TN (mg/L)		TN ($g/m^2/y$)				TKN (mg/L)		TKN ($g/m^2/y$)			
										Inflow	Outflow	Inflow	Outflow	Removed	%Removal	Inflow	Outflow	Inflow	Outflow	Removed	%Removal
1	13	Qtr-3	Mean	141.52	136.84	139.18	5.37	5.19	5.28	2.08	1.21	40.61	25.19	15.42	38%	1.95	1.19	38.15	24.67	13.48	35%
			Stdev	7.77	26.16	14.91	0.30	1.00	0.57	0.33	0.56	6.06	12.49			0.27	0.52	5.05	11.88		
			Max	144.70	169.16	156.84	5.50	6.41	5.94	2.40	1.74	45.57	34.80			2.17	1.66	42.16	33.20		
			Min	123.92	94.85	119.71	4.69	3.59	4.53	1.46	0.63	29.18	11.08			1.46	0.63	29.18	11.10		
			N	7	7	7	7	7	7	7	3	7	3			7	3	7	3		
1	13	Qtr-4	Mean	144.63	181.73	163.18	5.48	6.88	6.18	1.14	0.81	26.01	24.55	1.46	6%	1.10	0.81	25.35	24.55	0.80	3%
			Stdev	0.21	32.66	16.23	0.06	1.20	0.58	0.44	0.36	7.66	10.88			0.44	0.36	7.38	10.88		
			Max	144.86	203.52	174.05	5.52	7.61	6.52	1.71	1.16	34.38	32.24			1.67	1.16	33.60	32.24		
			Min	144.45	144.18	144.52	5.41	5.50	5.51	0.66	0.44	19.36	16.86			0.61	0.44	19.36	16.86		
			N	3	3	3	3	3	3	4	3	3	2			4	3	3	2		
2	8	Qtr-3	Mean	141.52	144.68	143.10	5.38	5.50	5.44	2.00	0.90	39.10	16.79	22.31	57%	1.88	1.03	36.70	19.45	17.26	47%
			Stdev	7.77	20.27	10.38	0.29	0.77	0.39	0.64	0.25	12.10	6.62			0.61	0.45	11.73	10.21		
			Max	144.70	174.09	159.33	5.51	6.58	6.02	2.69	1.10	53.86	21.72			2.56	1.50	51.24	29.68		
			Min	123.92	108.54	126.53	4.73	4.11	4.79	0.86	0.62	17.21	9.26			0.72	0.62	14.48	9.26		
			N	7	7	7	7	7	7	7	3	7	3			7	3	7	3		
2	8	Qtr-4	Mean	144.63	115.93	130.28	5.52	4.42	4.97	1.11	1.01	25.01	16.90	8.11	32%	1.09	1.01	24.81	16.90	7.91	32%
			Stdev	0.21	32.74	16.39	0.04	1.22	0.59	0.36	0.37	5.51	2.51			0.36	0.37	5.22	2.51		
			Max	144.86	135.37	139.91	5.56	5.13	5.32	1.52	1.38	30.34	18.68			1.49	1.38	29.73	18.68		
			Min	144.45	78.13	111.35	5.47	3.00	4.28	0.70	0.65	19.34	15.13			0.65	0.65	19.34	15.13		
			N	3	3	3	3	3	3	4	3	3	2			4	3	3	2		
3	3	Qtr-3	Mean	115.46	200.90	158.18	4.38	7.70	6.04	2.01	1.21	32.32	26.93	5.40	17%	1.91	1.21	30.44	26.94	3.50	12%
			Stdev	31.18	127.47	55.89	1.13	5.06	2.24	0.46	0.47	11.36	13.22			0.43	0.47	10.38	13.19		
			Max	144.65	488.45	282.89	5.49	19.10	11.06	2.43	1.52	44.46	36.70			2.30	1.52	42.06	36.70		
			Min	77.31	129.58	124.12	2.99	4.88	4.80	1.28	0.67	15.94	11.89			1.15	0.67	15.94	11.93		
			N	7	7	7	7	7	7	7	3	7	3			7	3	7	3		
3	3	Qtr-4	Mean	99.82	87.30	93.56	3.85	3.34	3.59	1.72	0.93	25.78	16.33	9.45	37%	1.72	0.93	25.66	16.33	9.34	36%
			Stdev	39.01	54.26	45.88	1.24	1.88	1.53	1.27	0.36	12.72	2.41			1.27	0.36	12.83	2.41		
			Max	144.86	145.79	145.33	5.28	5.31	5.30	3.55	1.28	40.47	18.03			3.55	1.28	40.47	18.03		
			Min	77.26	38.62	57.94	3.12	1.57	2.35	0.78	0.57	18.37	14.62			0.78	0.57	18.02	14.62		
			N	3	3	3	3	3	3	4	3	3	2			4	3	3	2		

Exhibit 3-11
ENR Test Cell Mass Balance Nitrogen Data Summarized by Project Quarter

Treatment	Cell	Time-Period	Stats	NO_2NO^3 (mg/L) Inflow	NO_2NO^3 (mg/L) Outflow	NO_2NO^3 ($g/m^2/y$) Inflow	NO_2NO^3 ($g/m^2/y$) Outflow	NO_2NO^3 ($g/m^2/y$) Removed	NO_2NO^3 ($g/m^2/y$) %Removal	NH_3 (mg/L) Inflow	NH_3 (mg/L) Outflow	NH_3 ($g/m^2/y$) Inflow	NH_3 ($g/m^2/y$) Outflow	NH_3 ($g/m^2/y$) Removed	NH_3 ($g/m^2/y$) %Removal	N_ORG (mg/L) Inflow	N_ORG (mg/L) Outflow	NH_3 ($g/m^2/y$) Inflow	NH_3 ($g/m^2/y$) Outflow	NH_3 ($g/m^2/y$) Removed	NH_3 ($g/m^2/y$) %Removal
1	13	Qtr-3	Mean	0.13	0.04	2.53	0.87	1.66	66%	0.06	0.02	1.24	0.41	0.84	67%	1.69	1.17	33.81	24.26	9.55	28%
			Stdev	0.07	0.03	1.28	0.62			0.07	0.00	1.46	0.06			0.26	0.52	5.24	11.84		
			Max	0.24	0.08	4.06	1.58			0.15	0.02	2.93	0.47			1.95	1.64	39.23	32.80		
			Min	0.03	0.03	0.50	0.44			0.02	0.02	0.40	0.35			1.44	0.61	28.78	10.74		
			N	7	3	7	3			3	3	3	3			3	3	3	3		
1	13	Qtr-4	Mean	0.04	0.03	0.80	0.60	0.20	25%	0.05	0.03	0.83	0.85	-0.02	-2%	0.86	0.78	20.40	23.69	-3.30	-16%
			Stdev	0.01	0.00	0.30	0.14			0.03	0.02	0.61	0.64			0.29	0.35	2.04	10.24		
			Max	0.06	0.03	1.11	0.69			0.06	0.05	1.26	1.31			1.11	1.11	21.84	30.93		
			Min	0.03	0.03	0.50	0.50			0.02	0.02	0.40	0.40			0.55	0.42	18.96	16.46		
			N	4	3	3	2			3	3	2	2			3	3	2	2		
2	8	Qtr-3	Mean	0.13	0.02	2.46	0.38	2.08	85%	0.06	0.02	1.24	0.36	0.88	71%	1.36	1.01	27.34	19.08	8.26	30%
			Stdev	0.07	0.01	1.21	0.11			0.07	0.00	1.46	0.06			0.63	0.45	12.63	10.16		
			Max	0.22	0.03	3.83	0.49			0.15	0.02	2.93	0.40			1.95	1.48	39.22	29.29		
			Min	0.03	0.01	0.50	0.27			0.02	0.02	0.40	0.30			0.70	0.60	14.07	8.96		
			N	7	3	7	3			3	3	3	3			3	3	3	3		
2	8	Qtr-4	Mean	0.03	0.03	0.54	0.37	0.17	32%	0.05	0.03	0.93	0.44	0.49	52%	0.90	0.98	21.42	16.46	4.96	23%
			Stdev	0.01	0.00	0.07	0.14			0.03	0.02	0.75	0.10			0.29	0.35	3.51	2.61		
			Max	0.05	0.03	0.62	0.47			0.07	0.05	1.46	0.52			1.18	1.33	23.90	18.30		
			Min	0.03	0.03	0.50	0.27			0.02	0.02	0.40	0.37			0.59	0.63	18.94	14.61		
			N	4	3	3	2			3	3	2	2			3	3	2	2		
3	3	Qtr-3	Mean	0.11	0.02	1.91	0.49	1.42	74%	0.06	0.02	1.18	0.43	0.75	64%	1.51	1.19	25.77	26.51	-0.74	-3%
			Stdev	0.06	0.00	1.15	0.16			0.07	0.00	1.51	0.07			0.42	0.47	12.05	13.13		
			Max	0.19	0.03	3.25	0.60			0.15	0.02	2.92	0.48			1.95	1.50	39.14	36.22		
			Min	0.03	0.02	0.27	0.30			0.02	0.02	0.22	0.36			1.13	0.65	15.73	11.57		
			N	7	3	7	3			3	3	3	3			3	3	3	3		
3	3	Qtr-4	Mean	0.03	0.03	0.37	0.39	-0.01	-3%	0.03	0.03	0.49	0.46	0.03	7%	1.73	0.90	28.99	15.86	13.12	45%
			Stdev	0.00	0.00	0.10	0.14			0.02	0.02	0.15	0.11			1.53	0.34	15.38	2.52		
			Max	0.03	0.03	0.48	0.48			0.05	0.05	0.60	0.54			3.50	1.23	39.87	17.65		
			Min	0.03	0.03	0.29	0.29			0.02	0.02	0.39	0.39			0.76	0.55	18.11	14.08		
			N	4	3	3	2			3	3	2	2			3	3	2	2		

stored in the top 10 cm of soil in Treatment 1 was relatively constant, averaging approximately 15.8 g/m^2 since startup.

EXHIBIT 3-12
ENR PSTA Test Cells Sediment Data Summary

Treatment	Date	Density (g/cm^3)	Solids (%)	Bulk Den (g/cm^3)	Vol Solids (%)	TP (mg/kg)	TIP (mg/kg)	TKN (mg/kg)	TOC (mg/kg)
1	Feb-99	0.92	31.40	0.32		467.7	454.0		
1	Apr-99	0.90	51.15	0.43		380.5	384.1		
1	May-99	1.16	39.50	0.46		367.9	306.8	1,071.5	48,850.0
1	Jun-99	1.25	42.00	0.52	42.25	300.1	237.7		
1	Jul-99	1.28	40.50	0.52		286.3	227.7		
2	Feb-99	1.91	71.18	1.36		875.6	876.5		
2	Apr-99	1.93	69.80	1.35		770.1	785.3		
2	May-99	1.93	70.00	1.35		855.5	764.8	51.8	4,915.0
2	Jun-99	2.03	81.00	1.64	8.62	791.4	730.2		
2	Jul-99	2.00	78.00	1.56		814.4	720.3		
3	Feb-99	1.90	67.55	1.28		1034.4	1030.8		
3	Apr-99	1.90	70.25	1.33		879.2	873.4		
3	May-99	1.80	69.50	1.25		866.7	735.3	74.7	4,655.0
3	Jun-99	1.91	78.00	1.49	6.76	873.3	764.0		
3	Jul-99	1.96	73.50	1.44		729.1	824.0		

Note(s):
Treatment 1 = Cell 13
Treatment 2 = Cell 8
Treatment 3 = Cell 3

In Treatment 2 (Test Cell 8), the average TP concentration varied between 770.1 and 875.6 mg/kg with an average TIP concentration between 720.3 and 876.5 mg/kg. TP and TIP were at their greatest concentrations during the initial sampling event (February 1999), and TIP declined in the succeeding samples. TP concentration did not exhibit the decreasing trend as did Treatment 1. The TP measured in the top 10 cm of shellrock soils in Treatment 2 was somewhat variable, ranging from 104 to 130 g/m^2 and averaging 118 g/m^2 since startup.

In Treatment 3 (Test Cell 3), the average TP concentration varied between 729.1 and 1,034.4 mg/kg with an average TIP concentration varying between 735.3 and 1,030.8 mg/kg. TP and TIP were observed at their greatest concentrations during the initial sampling event (February 1999) of the three Test Cells. Treatment 3 exhibited an initial decline in TP and TIP concentrations but became variable in June and July. The TP stored in the top 10 cm of shellrock soils in Treatment 3 was variable, ranging from 105 to 133 g/m^2 with an average of 120 g/m^2.

Nitrogen: The peat soils of Treatment 1 (Test Cell 13) exhibited an average TKN concentration of 1,071.5 mg/kg. In contrast to the peat soils in Treatment 1, Treatments 2 and 3 displayed lower average TKN measurements of 51.8 and 74.7 mg/kg, respectively.

Total Organic Carbon: The peat soils of Treatment 1 (Test Cell 13) exhibited a significantly greater average TOC concentration of 48,850 mg/kg in comparison to the mineral soils of Treatments 2 and 3 (Test Cells 8 and 3, respectively). TOC concentrations in Treatments 2 and 3 averaged 4,915 and 4,655 mg/kg, respectively.

3.7 Biological Analyses

Algal and macrophytic plant communities are being closely monitored in the PSTA Test Cells. The indices chosen for these studies are intended to characterize the changes in these communities over time and to contrast the effects of various experimental treatments. Measured parameters include percent cover, biomass, species composition, algal cell counts and biovolumes, chlorophyll, and nutrient content with an emphasis on phosphorus. In addition to these population level studies, ecosystem level response is being estimated using DO dynamics as an indicator of community metabolism.

3.7.1 Plant Cover

Plant cover in the PSTA Test Cells were estimated visually each month. An observer estimated cover of each of the following five plant groups in three zones within each PSTA Test Cell:

- Blue-green algal mat
- Green algal mat
- Floating aquatic plants
- Submerged aquatic plants
- Emergent macrophytes

The three zones used for estimating plant cover are the areas delimited by the two boardwalks in each cell. Plant cover is estimated in 1 of 10 cover categories and the mid-value of each category is used for averaging cover values from the three zones. These 10 cover categories include:

1. <1 percent
2. 1–5 percent
3. 5–10 percent
4. 10–25 percent
5. 25–50 percent
6. 50–75 percent
7. 75–90 percent
8. 90–95 percent
9. 95–99 percent
10. >99 percent

Exhibit 3-13 summarizes the plant cover estimates for the PSTA Test Cells for the first two quarters of operation. Data are presented by treatment number. Plant cover has increased dramatically in all three of the PSTA Test Cells. This cover is dominated by macrophytes in all cells, with greater than 100 percent macrophyte cover estimated in Treatment 1 (Test Cell 13). In July this peat-based cell had approximately 92.5 percent cover by submerged aquatic macrophytes (dominated by hydrilla [*Hydrilla verticillata*] and stonewort [*Chara* sp.]) and 17.5 percent cover by emergent macrophytes. Emergent macrophyte cover is approximately evenly shared by the planted species spikerush (*Eleocharis cellulosa*) and volunteer specimens of cattail (*Typha* sp). Blue-green algal mats covered approximately 17.5 percent of this cell during the July sampling event. Coverage by green algal mats and floating aquatic plants was insignificant.

EXHIBIT 3-13
Summary of Algae and Macrophyte Percent Cover Estimates in the PSTA Test Cells, February to July 1999

Treatment	Date	Blue-Green Algal Mat	Green Algal Mat	Emergent Macrophytes	Floating Aquatic Plants	Submerged Aquatic Plants	Macrophyte % Cover	Total % Cover
1	Feb-99	0.7%	0.0%	2.3%	0.0%	8.7%	11.0%	11.7%
1	Mar-99	1.0%	0.2%	2.3%	0.0%	13.3%	15.6%	16.8%
1	Apr-99	14.2%	14.2%	7.5%	3.0%	54.2%	64.7%	93.0%
1	May-99	3.0%	0.0%	7.5%	0.0%	97.0%	104.5%	107.5%
1	Jun-99	10.8%	0.0%	17.5%	0.0%	92.5%	110.0%	120.8%
1	Jul-99	17.5%	0.7%	17.5%	0.0%	92.5%	110.0%	128.2%
2	Feb-99	0.3%	0.0%	1.0%	0.0%	0.3%	1.3%	1.7%
2	Mar-99	0.8%	0.2%	2.0%	0.0%	0.8%	2.8%	3.8%
2	Apr-99	7.5%	7.5%	3.0%	3.0%	7.5%	13.5%	28.5%
2	May-99	2.3%	0.3%	3.0%	0.0%	10.8%	13.8%	16.5%
2	Jun-99	3.0%	0.0%	10.8%	0.0%	17.5%	28.3%	31.3%
2	Jul-99	3.0%	0.7%	10.8%	0.0%	17.5%	28.3%	32.0%
3	Feb-99	0.7%	0.3%	1.0%	0.0%	0.3%	1.3%	2.3%
3	Mar-99	1.3%	0.8%	2.0%	0.0%	2.3%	4.3%	6.4%
3	Apr-99	7.5%	7.5%	3.0%	3.0%	7.5%	13.5%	28.5%
3	May-99	4.5%	0.3%	7.5%	0.0%	20.8%	28.3%	33.2%
3	Jun-99	3.0%	0.3%	17.5%	0.0%	17.5%	35.0%	38.3%
3	Jul-99	3.0%	0.7%	17.5%	0.0%	17.5%	35.0%	38.7%

In contrast to the peat-based Test Cell, Treatments 2 and 3 (Test Cells 8 and 3, respectively) with shellrock substrate had less cover by all species of plants. Total plant cover was estimated as 32 percent in Treatment 2 and 39 percent in Treatment 3. Cover in these cells is also dominated by submerged and emergent macrophytes, principally hydrilla, stonewort, spikerush, and smaller populations of cattails. Total macrophyte cover is slightly higher in Treatment 3 (35 percent) compared to Treatment 2 (28 percent). This difference is the result of a relatively large difference between the emergent macrophyte cover in the two cells and may be a treatment effect from the variable water regime in Treatment 3. Submerged plant cover in both of these cells averaged 17.5 percent in July. Algal mats covered less than 4 percent of each of these two cells during this quarter, with blue-greens dominating.

3.7.2 Periphyton Community

Periphyton cores were collected monthly from the PSTA Test Cells. A single sample is collected from a randomly selected location along each of the two boardwalks and analyzed separately. This sample is delineated by a large water column sampling tube (206 cm^2 bottom area) and several smaller benthic cores (12.4 cm^2 each) are collected inside of this column. All floating, submerged, and rooted plant material is removed from the column sampler prior to coring the benthic algae. Macrophytes are handled separately for identification and dry weight analysis. All water and periphyton are blended and composited so that they represent a collection from a known bottom surface area. All data for algal counts, chlorophyll, phosphorus, etc. are reported as the mass per m^2 of bottom area. It is difficult to sample the benthic algae without incorporating an unwanted and unquantified amount of soil in the samples. This problem was particularly acute at the beginning of the project before development of a relatively discrete benthic algal mat. All periphyton data must be evaluated with this sampling difficulty in mind. All biomass samples include a component of soil; however, the nature of this soil is very different between the shellrock and peat treatments, and the proportion of soil in these samples has declined during the period of study.

Exhibit 3-14 summarizes periphyton sample data for the PSTA Test Cells since the beginning of the study. Biomass numbers must be interpreted in light of the cautions described above. The peat soils in Treatment 1 (Test Cell 13) are highly organic, and their occurrence in samples is demonstrated by the very high ash free dry weights recorded from February through May. The fraction of this material sampled was greatly reduced in the June and July samples, and these numbers probably represent a good estimate of actual average periphyton biomass in this treatment (between 494 and 763 g/m^2). Ash weights for these samples indicate a fairly large mineral residue. A large fraction of this ash appears to be calcium (18 to 26 percent).

Estimated periphyton ash free dry weight biomass in the samples from Treatments 2 and 3 generally increased through May and June and then declined in July. Average biomass in July was 118 and 112 g/m^2 in these two treatments. Calcium comprises between 17 and 27 percent of the ash in these samples.

Total and inorganic phosphorus and TKN concentrations measured in these samples were variable.

Chlorophyll provides a more direct method of estimation of algal populations in these periphyton samples. Chlorophyll concentrations corrected for phaeophytin ranged from 24 to 209 milligrams per square meter (mg/m^2) in the July samples. Chlorophyll levels were an order of magnitude lower in the shellrock-based Test Cell treatments than in the peat-based treatment.

Detailed algal taxonomy and cell counts are being conducted on all of these periphyton samples. Although incorporated soils sometimes make counting imprecise, these cell numbers and their associated volumes provide the best indicator of actual periphyton community structure.

As shown in Exhibit 3-14, the average number of cells in Treatment 1 (Test Cell 13) has varied between approximately 16 and 67 x 10^9 per m^2 with an average of 18.5 to 39 taxa represented in the counts. Blue-green algae have dominated the cell counts in these samples. Average total cell counts peaked in the June samples and declined in the July samples. The algal biovolume in these samples has varied between 18.4 and 29.8 cm^3/m^2. The Shannon Weaver Diversity Index (SWDI) has varied between 2.9 and 3.7 units, and evenness has varied between 0.7 and 0.71.

In Treatment 2 (Test Cell 8), the average number of cells has varied between approximately 8.9 and 34 x 10^9 per m^2 with an average of 18.5 to 39 taxa represented in the counts. Blue-

Exhibit 3-14
Summary of Periphyton Data from the PSTA Test Cells, February to July 1999

Treatment	Date	Periphyton Biomass (g/m^2)			Ca	Chl_a (corr)	Phaeo.	TP	TIP	TKN	Blue Green Algae		Diatoms		Green Algae		Other taxa		Total taxa		Biovolume	Evenness	SWDI
		Ash Wt	Dry Wt	AFDW	(g/m^2)	(mg/m^2)	(mg/m^2)	(g/m^2)	(g/m^2)	(g/m^2)	(10^6 cell/ m^2)	(# taxa)	(10^6 cell/ m^2)	(# taxa)	(10^6 cell/ m^2)	(# taxa)	(10^6 cell /m^2)	(# taxa)	(10^6 cell/ m^2)	(# taxa)	(cm^3/m^2)		
1	Feb-99	1090.7	1718.1	627.4	338.0	65.91	14.60	0.872	0.041								0	0.0					
1	Apr-99	2938.1	4754.1	1816.1	751.7	28.31	29.44	2.338	0.598		11443	2.5	3152	13.0	1366	3.0	0	0.0	15962	18.5		0.695	2.93
1	May-99	3351.8	5040.6	1688.8	641.9	211.61	112.40	1.635	0.716	9.21	18198	4.0	6432	24.5	6058	10.5	0	0.0	30688	39.0	18.38	0.698	3.68
1	Jun-99	1914.5	2677.3	762.8	349.9	419.35	106.29	1.139	0.044		42063	7.5	4138	13.0	20362	9.0	0	0.0	66563	29.5	29.75	0.710	3.45
1	Jul-99	863.6	1340.9	494.3	224.7	208.71	18.89	0.662	0.243		16876	8.5	1008	9.5	2116	10.0	0	0.0	20000	28.0	15.96	0.692	3.32
2	Feb-99	300.1	339.6	39.5	187.4	22.36	1.77	0.156	0.010								0	0.0					
2	Apr-99	536.8	702.5	166.8	93.6	3.61	0.92	0.287	0.145		5839	4.5	915	11.0	2044	14.0	87	4.0	8842	31.5		0.634	3.16
2	May-99	738.3	933.0	194.7	169.8	32.39	10.79	0.626	0.339	1.60	8661	10.0	1921	23.5	778	8.0	0	0.0	11360	41.5	8.52	0.718	3.86
2	Jun-99	626.0	803.8	177.8	132.9	24.27	1.27	0.597	0.300		28889	12.0	3743	14.5	1368	8.5	0	0.0	34000	35.0	45.37	0.746	3.83
2	Jul-99	324.8	443.0	118.2	87.3	23.57	1.17	0.254	0.129		16675	13.5	2318	9.0	1361	7.0	25	0.5	20379	30.0	2.43	0.759	3.73
3	Feb-99	353.0	413.2	60.2	155.0	23.82	15.30	0.204	0.009								0	0.0					
3	Apr-99	291.4	385.2	95.4	33.9	1.81	2.18	0.152	0.043		1363	5.0	331	12.5	977	14.0	183	3.0	2853	34.5		0.759	3.87
3	May-99	199.1	307.2	108.2	35.0	13.68	4.04	0.087	0.033	0.64	4301	8.5	962	18.0	696	11.0	24	1.5	5983	39.0	1.23	0.725	3.83
3	Jun-99	765.4	990.6	225.1	137.5	40.56	30.34	0.603	0.210		18153	11.5	2057	17.0	1176	6.0	0	0.0	21385	34.5	3.55	0.714	3.64
3	Jul-99	351.0	463.8	112.4	58.7	25.36	6.22	0.173	0.070		20196	14.0	1310	10.5	1835	7.5	56	1.0	23397	33.0	3.05	0.792	3.99

Notes:

Periphyton Biomass (g/m^2): [Weight (mg/L)] * [Total Sample Volume (mL) / ((# Small Cores * 12.4 (cm^2)) * 0.01]

Ca (g/m^2): Ca (mg/L) * [Total Sample Volume (mL) / ((# Small Cores * 12.4 (cm^2)) * 0.01]

Chlorophyll (mg/m^2): Chlorophyll (ug/L) * [Total Sample Volume (mL) / ((# Small Cores * 12.4 (cm^2)) * 0.01]

Biovolume (cm^3/m^2): [Biovolume (um^3/ml)] * 10^{-6} * [Total Sample Volume (mL) / ((# Small Cores * 12.4 (cm^2)) * 0.01]

Taxa (# cells/m^2)*10^6: (Taxa (# cells/ml) * 10^6 * [Total Sample Volume (mL) / ((# Small Cores * 12.4 (cm^2)) * 0.01]) / 10^6

green algae have dominated the cell counts in these samples. Average total cell counts peaked in the June samples and declined in the July samples. The algal biovolume in these samples has varied between 2.4 and 45.4 cm^3/m^2. The SWDI has varied between 3.2 and 3.9 units, and evenness has varied between 0.63 and 0.76.

In Treatment 3 (Test Cell 3), the average number of cells has varied between approximately 2.9 and 23 x 10^9 per m^2 with an average of 33 to 39 taxa represented in the counts. Blue-green algae have dominated the cell counts in these samples. Average total cell counts rose each month but were similar in the June and July samples. The algal biovolume in these samples has varied between 1.2 and 3.6 cm^3/m^2. The SWDI has varied between 3.6 and 4.0, units and evenness has varied between 0.71 and 0.79.

These periphyton data indicate that algal populations have highest biovolume, chlorophyll, and biomass in the peat-based Test Cell (Treatment 1). Algal diversity in this cell is typically lower than in the other two treatments. Cell counts are also typically higher in this treatment. Blue-green species dominate the algal populations in all three of these Test Cells. There are no apparent consistent differences between the two shellrock treatments for any of the periphyton parameters.

3.8 Ecosystem Metabolism

Aquatic ecosystems contain numerous biological processes that consume and produce DO. The oxygen-consuming processes are referred to as community respiration (CR) and include cellular metabolism and decomposition processes. The oxygen-producing processes are referred to as primary productivity and include photosynthetic activities of submerged algae and plants in response to the photosynthetically active radiation (PAR) or the input of light that can be used by the plants. These oxygen changes must be corrected for the effects of diffusion of oxygen into or out of the water column. A diffusion coefficient of 0.20 g of oxygen per square meter per hour ($O_2/m^2/hr$) has been used for preliminary analysis until actual diffusion rates are measured in the field.

Changes in DO content of the water column during a daily period can be used to estimate the processes of community respiration and photosynthesis. The combination of respiration and photosynthesis is called community metabolism (CM). This is also equal to gross primary productivity (GPP) that includes the total oxygen fixed by the ecosystem. Respiration continues throughout the daylight and nighttime hours and is reported as CR. The difference between CM or GPP and CR is called net primary production (NPP). NPP can be reported for the full 24-hour day or just for the daylight portion (NPP day). The 24-hour NPP is an estimate of the accumulation of fixed organic matter. The approximate conversion between oxygen and carbon is 1:1. The conversion between oxygen and ash free dry weight is approximately 1:2. GPP is sometimes expressed as an efficiency by dividing the GPP converted to kilocalories (kcal) assuming a conversion of about 10 kcal/g O_2 (Odum 1971) and converting PAR to kcal by the assumption that one Einstein (mole of photons) is equal to 52.27 kcal.

Exhibit 3-15 summarizes the ecosystem metabolism estimates for the PSTA Test Cells to-date. CM of the PSTA Test Cell ecosystems has generally increased during the period of this research. Because the initial colonization of Treatment 1 by submerged aquatic plants, this cell initially had the highest metabolism and increased from approximately 1.7 g $O_2/m^2/d$

in March to 6.4 g $O_2/m^2/d$ in May, before declining to 4.5 g $O_2/m^2/d$ in June. Insufficient data were collected from this Test Cell to estimate CM in February and July. Efficiency increased to approximately 2.8 percent in this cell by June. NPP increased in this cell to 1.25 g $O_2/m^2/d$ in May and declined to 0.68 g $O_2/m^2/d$ in June. Based on the average estimated NPP during this period (0.75 g $O_2/m^2/d$) and the conversions described previously, a net accumulation is expected of approximately 1.5 g ash free dry weight per square meter per day (afdw/m^2/d) or 194 g afdw/m^2 during the 130-day operational period. This value is less than the biomass of 763 g afdw/m^2 measured in June and may provide a more accurate estimate of accrued biomass than the suspect periphyton core samples from this Test Cell.

EXHIBIT 3-15

Summary of Ecosystem Metabolism Data from the PSTA Test Cells, February to July 1999

Treatment	Time Period	NPP(day) g $O_2/m^2/d$	GPP(day) g $O_2/m^2/d$	CR(24hr) g $O_2/m^2/d$	CM(24hr) g $O_2/m^2/d$	NPP(24hr) g $O_2/m^2/d$	Avg Night Res g $O_2/m^2/d$	PAR(24hr) E/m^2/d	Efficiency %
1	Mar-99	1.03	1.69	1.29	1.69	0.39	0.05	41.4	0.78
1	Apr-99	1.52	2.57	1.89	2.57	0.67	0.08	42.5	1.15
1	May-99	3.09	6.44	5.19	6.44	1.25	0.22	44.9	2.74
1	Jun-99	2.02	4.53	3.85	4.53	0.68	0.16	31.1	2.79
2	Feb-99	0.44	1.46	1.83	1.46	-0.38	0.08	32.2	0.86
2	Mar-99	0.58	1.63	1.80	1.63	-0.17	0.07	40.2	0.77
2	Apr-99	1.12	2.76	2.74	2.76	0.02	0.11	44.9	1.18
2	May-99	1.48	3.27	2.80	3.27	0.47	0.12	45.8	1.37
2	Jun-99	2.39	5.05	4.04	5.05	1.01	0.17	33.4	2.90
2	Jul-99	2.27	4.79	3.83	4.79	0.96	0.16	37.7	2.43
3	Feb-99	-0.15	0.36	0.95	0.36	-0.59	0.04	34.6	0.20
3	Mar-99	0.50	1.57	1.84	1.57	-0.27	0.08	40.6	0.74
3	Apr-99	0.63	1.79	1.91	1.79	-0.12	0.08	45.9	0.74
3	May-99	0.55	2.35	2.80	2.35	-0.45	0.12	45.2	1.00
3	Jun-99	0.48	2.57	3.18	2.57	-0.61	0.13	32.0	1.54
3	Jul-99	1.04	2.99	2.97	2.99	0.03	0.12	42.3	1.35

Note: Efficiency is calculated with above-water PAR, and the assumption that 1 g O_2/m^2 equals 10 kcal and 1 Einstein (E) of photons equals 52.27 kcal.

CM has generally increased in Treatments 2 and 3 during the period of research. Estimated average July values were 4.8 and 3.0 g $O_2/m^2/d$ in Treatments 2 and 3, respectively. Estimated rates of NPP in Treatment 2 were negative early in the project and have increased to positive values in April through July. NPP increased in this cell to 1.01 g $O_2/m^2/d$ in June and declined to 0.96 g $O_2/m^2/d$ in July. Based on the average estimated NPP during this period (0.38 g $O_2/m^2/d$) and the conversions described above, a net accumulation is expected of approximately 0.64 g afdw/m^2/d or 102 g afdw/m^2 during the 161-day operational period. This value is not greatly different from the biomass of 118 g afdw/m^2 measured in July. NPP estimates for Treatment 3 were negative until July. This finding conflicts with the measured periphyton biomass accumulation in this cell. Additional data will need to be collected to help explain this apparent discrepancy. Efficiencies in Treatments 2 and 3 in July were estimated as 2.4 and 1.4 percent, respectively.

3.8.1 PAR Extinction

PAR is defined as the incident solar radiation in the range of wavelengths from 400 to 700 nanometers (nm). These wavelengths include much of the energy directly used in photosynthesis by algae and macrophytic plants. Attenuation of PAR through the water column is an indicator of how much useable solar energy is reaching benthic algae in the PSTA Test Cells. The extinction of this PAR is compared between different systems by calculating an extinction coefficient, n as:

$$n = (\ln I_o - \ln I_Z)/Z$$

where:

n = extinction coefficient in m^{-1}
I_o = incident PAR just below the water surface ($\mu mol/m^2/s$)
I_Z = PAR at a distance Z below the surface measurement ($\mu mol/m^2/s$)
Z = distance between measurements (m)

Exhibit 3-16 summarizes the PAR extinction data for the PSTA Test Cells since the project started in February 1999. Monthly average PAR extinction coefficients generally ranged between 1.03 and 2.94 m^{-1}. Extinction coefficients were generally higher in Treatment 1 (peat-based) compared to the other two treatments.

EXHIBIT 3-16
Summary of PAR Extinction Measurements from the PSTA Test Cells, February to July 1999

Treatment	Date	Water Depth (m)	PAR ($\mu mol/m^2/s$) Surface	Bottom	Z (m)	Ext Coeff (m^{-1})
1	Feb-99	0.66	1741.3	448.3	0.47	2.94
1	Mar-99	0.67	1432.2	481.3	0.54	1.84
1	Apr-99	0.64	1261.7	458.9	0.52	2.01
1	May-99	0.46	2039.2	1258.2	0.34	1.48
1	Jun-99	0.66	1619.4	594.2	0.58	1.97
1	Jul-99	0.67	880.7	377.0	0.54	2.38
2	Feb-99	0.62	752.6	356.8	0.41	1.86
2	Mar-99	0.60	1356.9	770.1	0.44	1.36
2	Apr-99	0.64	1396.8	653.8	0.48	1.57
2	May-99	0.46	1081.1	610.9	0.34	1.67
2	Jun-99	0.61	2095.5	1117.7	0.49	1.29
2	Jul-99	0.62	1752.5	1037.5	0.50	1.03
3	Feb-99	0.68	941.1	253.0	0.47	2.73
3	Mar-99	0.71	1902.8	747.4	0.60	1.48
3	Apr-99	0.63	1436.7	603.7	0.51	1.71
3	May-99	0.43	1251.6	784.9	0.30	1.89
3	Jun-99	0.82	1506.2	539.5	0.70	1.47
3	Jul-99	0.82	1897.6	725.3	0.70	1.26

Note: Extinction coefficient = $(\ln PAR_{surf} - \ln PAR_{bot})/z$ and z = water depth -.122 m

SECTION 4

Porta-PSTA Mesocosms

4.1 Porta-PSTA Treatments

A total of 24 Porta-PSTAs are deployed at the South STRC within the ENR. Six different priority experimental treatments are replicated three times for a total of 18 mesocosms. The priority experimental treatments identified for Phase I include:

- Substrate type (peat vs. shellrock)
- Water depth (60 cm or 30 cm average depth)
- Hydraulic loading rate (6 vs 12 cm/d)
- Dry-down (0 to 60 cm variable water depth with periodic dry-downs)

One set of three shellrock mesocosms (Treatment 6) receives variable inflows and has variable water depth to simulate full-scale PSTA operation.

Six additional unreplicated treatments are being demonstrated in the remaining six mesocosms. These treatments were included to demonstrate Porta-PSTA performance in treatment configurations that may be less optimal than those covered in the replicated mesocosms. These treatments include:

- Two Porta-PSTAs with sand and macrophytes to act as substrate controls.
- A test of the effect of excluding all plants from both shellrock- and peat-based Porta-PSTAs using Aquashade dye (plantless controls).
- Two Porta-PSTAs that vary in depth:width ratio while holding other variables constant to assess the effects of walls and their surface area:volume effect on Porta-PSTA performance.

Porta-PSTA experimental treatments are summarized in Exhibit 4-1.

4.2 Water Regime

The PSTA water regime includes the components of water depth fluctuations, HLR, and water mass balance. Exhibit 4-2 summarizes the Porta-PSTA water regime data for the 3rd and 4th quarters. Water level, inflow, outflow, and HLR charts are presented in Appendix A.

4.2.1 Water Depth

Water level measurements in the Porta-PSTA mesocosms were recorded by reading the staff gauge installed near the outflow of each tank. Readings were taken approximately twice per week.

EXHIBIT 4-1
Randomized Porta-PSTA Mesocosm/Treatment Combinations

Treatment #	Substrate	Periphyton	Macrophytes	Water Depth (cm)	HLR (cm/d)	Width (m)	Tank #
1a	Peat	Yes	Yes	60	6	1	9
1b	Peat	Yes	Yes	60	6	1	11
1c	Peat	Yes	Yes	60	6	1	18
2a	Shellrock	Yes	Yes	60	6	1	7
2b	Shellrock	Yes	Yes	60	6	1	4
2c	Shellrock	Yes	Yes	60	6	1	8
3a	Peat	Yes	Yes	30	6	1	17
3b	Peat	Yes	Yes	30	6	1	14
3c	Peat	Yes	Yes	30	6	1	12
4a	Shellrock	Yes	Yes	30	6	1	10
4b	Shellrock	Yes	Yes	30	6	1	5
4c	Shellrock	Yes	Yes	30	6	1	3
5a	Shellrock	Yes	Yes	60	12	1	16
5b	Shellrock	Yes	Yes	60	12	1	2
5c	Shellrock	Yes	Yes	60	12	1	13
6a	Shellrock	Yes	Yes	0-60	6	1	6
6b	Shellrock	Yes	Yes	0-60	6	1	15
6c	Shellrock	Yes	Yes	0-60	6	1	1
7	Sand	Yes	Yes	30	6	1	19
8	Sand	Yes	Yes	60	6	1	20
9	Peat	No	No	60	6	1	21
10	Shellrock	No	No	60	6	1	22
11	Shellrock	Yes	Yes	30	6	3	23
12	Peat	Yes	Yes	30	6	3	24

4.2.2 Hydraulic Loading Rate

Water inflows to the Porta-PSTA Cells are estimated based on timed volume measurements at the inlet of each mesocosm. Outflows are estimated using the same method at each mesocosm outlet.

4.2.3 Water Balance

Exhibit 4-3 presents a monthly water balance for the period of record (April to July 1999). Rainfall and ET data were provided by the District. ET data were not available for June and

Exhibit 4-2

Summary of Water Regime Data at the Porta-PSTA Mesocosms

	Treatment																							
	1		2		3		4		5		6		7		8		9		10		11		12	
Parameter	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q	3rd Q	4th Q
Water Depth (m)																								
Avg	0.55	0.66	0.61	0.65	0.31	0.33	0.33	0.37	0.63	0.65	0.48	0.57	0.66	0.50	0.64	0.68	0.59	0.65	0.63	0.65	0.37	0.36	0.31	0.36
Max	0.63	0.69	0.62	0.65	0.33	0.42	0.33	0.43	0.65	0.67	0.63	0.66	0.66	0.68	0.64	0.72	0.59	0.65	0.63	0.65	0.37	0.57	0.31	0.38
Min	0.12	0.59	0.59	0.64	0.29	0.31	0.32	0.36	0.62	0.64	0.28	0.35	0.66	0.37	0.64	0.38	0.59	0.64	0.63	0.65	0.38	0.34	0.31	0.35
Std Dev	0.16	0.02	0.01	0.00	0.02	0.03	0.00	0.02	0.01	0.01	0.16	0.14	0.00	0.15	0.00	0.09	0.00	0.00	0.00	0.00	0.01	0.06	0.00	0.01
n	10	14	10	15	12	15	12	14	12	15	10	14	4	13	4	14	4	13	4	13	4	14	4	14
Inflow (m^3/d)																								
Avg	0.29	0.30	0.30	0.31	0.28	0.30	0.30	0.31	0.60	0.57	0.23	0.37	0.32	0.32	0.34	0.35	0.37	0.30	0.39	0.28	0.92	1.00	0.96	1.01
Max	0.43	0.46	0.72	0.39	0.45	0.36	0.71	0.40	0.81	0.72	0.58	0.59	0.45	0.40	0.46	0.73	0.98	0.36	2.88	0.34	1.44	1.07	1.27	1.13
Min	0.00	0.05	0.00	0.05	0.00	0.04	0.00	0.04	0.00	0.09	0.00	0.16	0.00	0.04	0.06	0.13	0.00	0.04	0.00	0.05	0.00	0.07	0.00	0.11
Std Dev	0.13	0.17	0.15	0.22	0.14	0.22	0.15	0.23	0.25	0.40	0.12	0.10	0.13	0.25	0.10	0.23	0.24	0.26	0.56	0.20	0.34	0.83	0.35	0.80
n	67	30	68	29	70	35	67	34	67	33	84	33	23	11	22	11	26	11	23	11	25	12	27	12
Outflow (m^3/d)																								
Avg	0.29	0.24	0.31	0.27	0.39	0.28	0.38	0.31	0.69	0.56	0.28	0.35	0.31	0.37	2.88	0.23	0.35	0.22	0.27	0.18	0.71	0.97	0.89	1.09
Max	0.56	0.44	0.43	0.52	0.55	0.58	0.43	0.94	0.72	0.91	0.40	0.58	0.32	0.75	2.88	0.45	0.35	0.39	0.27	0.36	0.72	1.40	0.92	1.40
Min	0.00	0.11	0.20	0.12	0.29	0.14	0.35	0.15	0.63	0.18	0.20	0.19	0.29	0.19	2.88	0.13	0.35	0.11	0.27	0.11	0.69	0.36	0.86	0.21
Std Dev	0.24	0.00	0.08	0.05	0.11	0.00	0.03	0.11	0.03	0.00	0.07	0.00	0.02	0.08	0.00	0.04	0.00	0.00	0.00	0.00	0.01	0.09	0.03	0.85
n	9	31	9	29	9	33	9	33	9	33	9	30	3	11	1	11	3	11	3	10	3	11	3	11
HLR (cm/d)																								
Avg	4.8	5.0	5.1	5.1	4.6	4.9	5.0	5.1	10.0	9.5	3.8	6.2	5.3	5.3	5.6	5.8	6.2	5.1	6.6	4.7	5.1	5.5	5.3	5.6
Max	7.2	7.7	12.0	6.5	7.4	6.1	11.8	6.7	13.6	12.0	9.6	9.9	7.4	6.6	7.7	12.2	16.3	5.9	48.0	5.6	8.0	6.0	7.0	6.3
Min	0.0	0.8	0.0	0.8	0.0	0.7	0.0	0.6	0.0	1.5	0.0	2.7	0.0	0.7	1.1	2.2	0.0	0.6	0.0	0.8	0.0	0.4	0.0	0.6
Std Dev	2.1	2.9	2.5	3.7	2.3	3.6	2.5	3.8	4.1	6.6	1.9	1.7	2.1	4.2	1.6	3.9	4.1	4.3	9.3	3.4	1.9	4.6	1.9	4.5
n	67	30	68	29	70	35	67	34	67	33	84	33	23	11	22	11	26	11	23	11	25	12	27	12

Exhibit 4-3
Water Balance for the Porta-PSTA Mesocosm Cells

		INFLOW		OUTFLOW		RAINFALL		ET		ΔSTORAGE	RESIDUAL	RESIDUAL
TREATMENT	MONTH	(m^3/d)	(m^3)	(m^3/d)	(m^3)	(in)	(m^3)	(mm)	(m^3)	(m^3)	(m^3)	(% of total inflow)
1	APR	0.32	9.61	0.35	10.37	0.71	0.11	129	0.77	-1.14	-0.28	-3%
	MAY	0.28	8.74	0.06	1.86	2.09	0.32	137	0.82	1.15	5.23	58%
	JUNE	0.34	10.07	0.32	9.52	12.54	1.91	150	0.90	-0.10	1.67	14%
	JULY	0.30	9.25	0.17	5.32	3.18	0.48	171	1.02	-0.03	3.42	35%
2	APR	0.29	8.70	0.34	10.15	0.71	0.11	129	0.77	-0.03	-2.09	-24%
	MAY	0.28	8.78	0.13	3.91	2.09	0.32	137	0.82	0.01	4.36	48%
	JUNE	0.35	10.46	0.37	10.97	12.54	1.91	150	0.90	0.01	0.50	4%
	JULY	0.31	9.50	0.25	7.73	3.18	0.48	171	1.02	0.01	1.23	12%
3	APR	0.26	7.79	0.31	9.36	0.71	0.11	129	0.77	0.00	-2.23	-28%
	MAY	0.32	9.97	0.18	5.51	2.09	0.32	137	0.82	0.01	3.95	38%
	JUNE	0.29	8.79	0.30	9.10	12.54	1.91	150	0.90	0.01	0.70	7%
	JULY	0.34	10.69	0.31	9.50	3.18	0.48	171	1.02	0.04	0.61	5%
4	APR	0.30	9.14	0.33	10.01	0.71	0.11	129	0.77	-0.01	-1.53	-17%
	MAY	0.28	8.69	0.17	5.25	2.09	0.32	137	0.82	0.02	2.92	32%
	JUNE	0.35	10.62	0.41	12.32	12.54	1.91	150	0.90	-0.01	-0.69	-5%
	JULY	0.33	10.33	0.29	8.97	3.18	0.48	171	1.02	0.01	0.82	8%
5	APR	0.57	17.18	0.68	20.45	0.71	0.11	129	0.77	0.02	-3.95	-23%
	MAY	0.55	16.96	0.24	7.44	2.09	0.32	137	0.82	0.00	9.02	52%
	JUNE	0.58	17.30	0.68	20.48	12.54	1.91	150	0.90	-0.04	-2.14	-11%
	JULY	0.67	20.67	0.58	17.97	3.18	0.48	171	1.02	0.02	2.15	10%
6	APR	0.17	4.99	0.19	5.83	0.71	0.11	129	0.77	-1.83	0.33	6%
	MAY	0.13	4.14	0.00	0.00	2.09	0.32	137	0.82	-0.01	3.64	82%
	JUNE	0.44	13.21	0.52	15.49	12.54	1.91	150	0.90	1.81	-3.08	-20%
	JULY	0.53	16.54	0.52	16.07	3.18	0.48	171	1.02	-0.01	-0.05	0%
7	APR	0.32	9.67	0.21	6.26	0.71	0.11	129	0.77	0.00	2.74	28%
	MAY	0.32	9.97	0.08	2.46	2.09	0.32	137	0.82	0.02	6.99	68%
	JUNE	0.30	9.10	0.75	22.54	12.54	1.91	150	0.90	-0.09	-12.34	-112%
	JULY	0.38	11.83	0.28	8.82	3.18	0.48	171	1.02	-1.76	4.23	34%
8	APR	0.39	11.59	0.29	8.64	0.71	0.11	129	0.77	0.00	2.29	20%
	MAY	0.30	9.15	0.04	1.23	2.09	0.32	137	0.82	0.02	7.40	78%
	JUNE	0.33	9.90	0.36	10.87	12.54	1.91	150	0.90	-0.27	0.31	3%
	JULY	0.39	11.94	0.14	4.32	3.18	0.48	171	1.02	-0.02	7.11	57%
9	APR	0.37	11.09	0.35	10.37	0.71	0.11	129	0.77	0.00	0.05	0%
	MAY	0.33	10.08	0.24	7.37	2.09	0.32	137	0.82	0.04	2.17	21%
	JUNE	0.36	10.69	0.39	11.59	12.54	1.91	150	0.90	0.00	0.11	1%
	JULY	0.27	8.37	0.20	6.31	3.18	0.48	171	1.02	-0.04	1.56	18%
10	APR	0.27	8.05	0.29	8.64	0.71	0.11	129	0.77	0.02	-1.28	-16%
	MAY	0.26	8.18	0.00	0.00	2.09	0.32	137	0.82	0.00	7.68	90%
	JUNE	0.33	10.01	0.36	10.94	12.54	1.91	150	0.90	0.00	0.08	1%
	JULY	0.29	9.00	0.11	3.52	3.18	0.48	171	1.02	0.00	4.94	52%
11	APR	0.90	27.05	1.07	31.97	0.71	0.11	129	0.77	0.07	-5.65	-21%
	MAY	1.00	31.07	0.54	16.63	2.09	0.32	137	0.82	0.02	13.92	44%
	JUNE	1.07	32.15	1.05	31.39	12.54	1.91	150	0.90	0.00	1.77	5%
	JULY	1.06	32.88	1.11	34.34	3.18	0.48	171	1.02	0.00	-1.99	-6%
12	APR	1.07	31.97	0.95	28.51	0.71	0.11	129	0.77	0.02	2.77	9%
	MAY	1.13	35.12	1.34	41.40	2.09	0.32	137	0.82	-0.05	-6.74	-19%
	JUNE	1.09	32.72	0.94	28.12	12.54	1.91	150	0.90	0.02	5.60	16%
	JULY	1.11	34.45	1.01	31.29	3.18	0.48	171	1.02	-0.02	2.64	8%

July. The average daily ET rate for May was 4.4 mm/d. June and July ET rates were assigned values of 5.0 mm/d and 5.5 mm/d, respectively; these interim water balance calculations will be replaced with actual records for June and July in future quarterly reports. Change in storage was estimated as the product of the mesocosm area and the change in water level between the beginning and end of each month. In general, higher residuals associated with the first month of operation can be attributed to flow variation associated with startup. Large residuals in May can be attributed to variation in measurement and estimation of inflow and outflow rates.

4.3 Tracer Studies

Tracer studies provide a means of estimating the mean hydraulic residence time (HRT) and degree of mixing in aquatic treatment systems (Kadlec and Knight, 1996). Because these analyses can offer significant insight into treatment performance, tracer studies required by the PSTA Research Plan (CH2M HILL, 1999a) are being conducted at the PSTA Test Cells and in the Porta-PSTA mesocosm tanks.

An initial tracer experiment was conducted at Tank 7 to evaluate sampling methods, determine sample frequency requirements, and investigate the feasibility of using sodium bromide (NaBr) as a tracer. The second series of experiments, conducted at Tanks 7, 10, and 23, were performed to compare the results generated by two tracers, NaBr and lithium chloride (LiCl). Tracer studies were conducted at the Porta-PSTA Mesocosm site (Tanks 7, 10, and 23) during the 3rd and 4th quarters. These studies were performed to estimate the mean hydraulic residence time (HRT) and to determine the degree of mixing. The two tracer studies are presented below.

4.3.1 Tank 7 Tracer Study (3rd Quarter)

The primary objectives of this tracer study are presented below:

- To evaluate and refine the testing procedures described in the technical memorandum, *Periphyton-based Stormwater Treatment Area (PSTA) Research and Development Project – Tracer Study Plan* (CH2M HILL, 1998). This test was primarily for the purpose of methods development.
- To evaluate the use of sodium bromide as a tracer to be used in conjunction with the lithium chloride solution proposed in the above-referenced document. Because bromide ion (Br^-) concentrations can be determined in the field, the total cost for lithium analyses may be reduced by sending a sub-set of the lithium samples to the laboratory.

Study conditions and results are summarized in Exhibits 4-4 and 4-5, respectively.

The tracer study data were interpreted following the methods summarized by Kadlec and Knight (1996). The measured concentration of Sample 1, 3.4 mg/L, was assumed to be the background concentration for the study. As indicated previously, the experiment could not be completed because the tank required structural repairs. Exhibit 4-5 presents a summary of the tracer study results. Appendix B presents the detailed calculations.

A portion of the tail of the curve was extrapolated based upon measured data following the peak of the distribution. The tail was extrapolated for 4-hour time steps from February 22,

Exhibit 4-4: Porta-PSTA Cell 7 Bromide Tracer Study

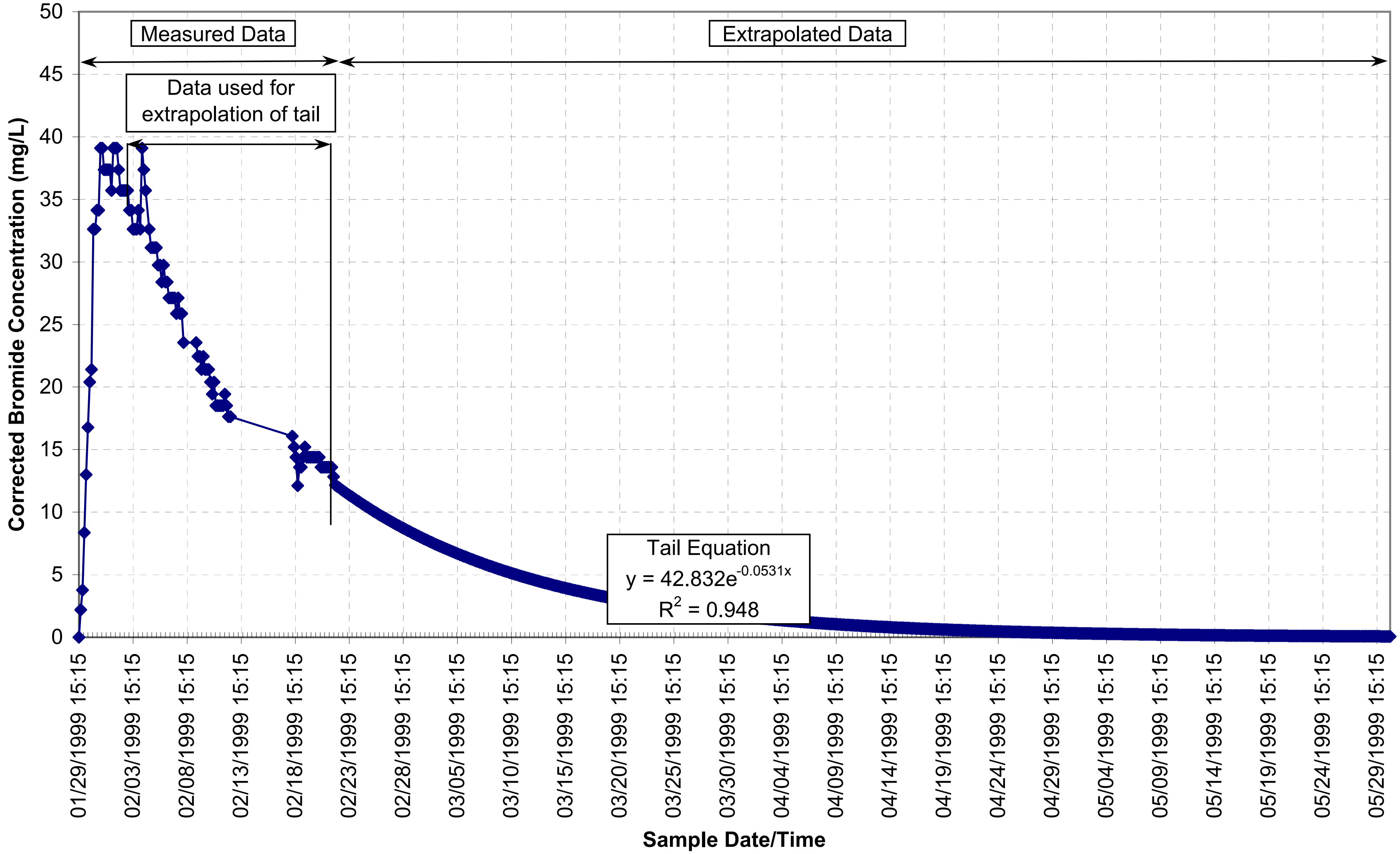


Exhibit 4-5
Summary of Tracer Study Results

PortaPSTA Tracer Test - Cell 7

Volume of NaBr Solution Applied:	**0.917 L**	**Nominal HRT:**	**10.83 d**
Concentration of Br Applied:	**332,030.25 mg/L**	**Avg. Flow:**	**0.36 m^3/d**
Mass of Br Applied:	**304.588 g**	**Avg. HLR:**	**6.0 cm/d**
Date/Time of Application:	**01/29/1999 15:15**	**Nominal Volume:**	**3.9 m^3**
Background Br Concentration:	**3.40 mg/L**		

Mass Recovery = 90%

Excel Solver Routine Used to determine Peclet Number. (Pe = 1/$\mathscr{D}$)

Mean Residence Time τ_a (d) =	**19.557**	**M1/M0**
σ^2 (d^2) =	**332.304**	**M2/M0**
Number of Tanks N =	**1.151**	**τ_a^2/σ^2**
Volumetric Efficiency =	**1.805**	**$\tau\alpha/\tau\nu$**
Dimensionless Variance =	**0.869**	**1/N**
Wetland Dispersion Number $\mathscr{D}$ =	**2.374**	**Solver**

$\mathscr{D}$
2.374
Dimensionless Variance Guess
Pe = 0.421278903 0.87319974

1999, at 04:30 to an endpoint at May 30, 1999, at 20:30. The endpoint of the experiment was selected at a point where the change in total mass diminished significantly with each consecutive time step.

An artifact of this extrapolation procedure is that complete mass recovery of the tracer can not be achieved because the manipulated curve becomes asymptotic to the background concentration. This procedure may also artificially lengthen the duration of the tracer study. However, the estimated 90 percent mass recovery is acceptable for the purposes of this initial study.

The calculated HRT for Tank 7 was estimated to be 19.6 days. This value exceeds the nominal HRT of 10.8 days. This experimental artifact could be the result of insufficient flow monitoring during this preliminary study. Lower inflows than desired during a portion of the study could result in the longer observed HRT. Another possible explanation of this artifact is adsorption/desorption of the bromide in the sediments. This possibility was tested by adding bromide to a jar containing shellrock. No bromide was lost from solution, which indicates that variable inflows are the likely explanation for the observed long residence time.

The number of tanks-in-series (1.2) estimated from this data set indicates that the system was relatively well mixed and does not follow plug-flow hydraulics. This condition is expected to change somewhat during the course of the research as wind mixing decreases in response to increasing periphyton and macrophyte cover in the PSTA mesocosms.

4.3.2 Tanks 7, 10, and 23 Tracer Study (4th Quarter)

A preliminary tracer study of PSTA Tank 7 in March 1999 validated the experimental approach and determined that sodium bromide is an effective tracer in lieu of or in conjunction with lithium chloride (CH2M HILL, 1999b).

An additional tracer study was conducted from April to June 1999 that simultaneously compared the effectiveness of two tracer solutions, NaBr and LiCl. The primary objectives of the study were:

- To characterize the hydraulic properties of Porta-PSTA tanks 7, 10, and 23
- To compare the results generated by two different tracer solutions
- To refine the experimental approach in preparation for tracer studies at the ENR Test Cells

4.3.2.1 Materials and Methods

Porta-PSTA Tanks 7, 10, and 23 were selected because they represent the full range of depth and volume treatments used for this mesocosm study. Flow data are presented in Appendix B. Exhibit 4-6 presents the design operating conditions for each experiment. Tracer experiment methodology followed that described in a previous technical memorandum (CH2M HILL, 1998).

EXHIBIT 4-6
Design Operating Conditions in Porta-PSTA Mesocosms Evaluated in the Tracer Study

Parameter	Tank 7	Tank 10	Tank 23
Flow (m^3/d)	0.36	0.36	1.08
Hydraulic Loading Rate (cm/d)	6.0	6.0	6.0
Depth (cm)	60	30	30
Surface Area (m^2)	6	6	18
Nominal Hydraulic Residence Time (d)	10	5	5

Using an aluminum yardstick, average water depths in each tank were measured to be 64.6 cm, 36.3 cm, and 33.5 cm for Tanks 7, 10, and 23, respectively.

Tracer spike solutions were prepared using 40 percent LiCl brine (approximately 83,000 mg/L as Li ion) and 40 percent NaBr brine (approximately 360,000 mg/L as Br ion) to yield average peak concentrations of 0.5 mg/L for lithium (as Li ion) and 200 mg/L for bromide (as Br ion). The sources of the LiCl and NaBr stock solutions were FMC Corporation, Gastonia, North Carolina, and Tetra Technologies, Inc., The Woodlands, Texas, respectively.

The tracer solutions for each tank were combined in 1-gallon containers, stirred, and diluted to a total volume of approximately 1 gallon with de-ionized water to reduce density differences between the tracer solutions and the feed water. The tracer solutions were applied to each tank for a period of approximately 2 minutes by pouring the contents of the 1-gallon containers into each tank at the location of the inlet pipe discharge. Tracer volumes and approximate diluted solution concentrations applied during the study are presented in Exhibit 4-7.

EXHIBIT 4-7
Summary of Tracer Volumes and Solution Concentrations Applied During Study

	Tank 7		Tank 10		Tank 23	
Tracer	Volume	Concentration	Volume	Concentration	Volume	Concentration
LiCl	25 mL	550 mg/L as Li	10 mL	220 mg/L as Li	35 mL	770 mg/L as Li
NaBr	1.6 L	152,000 mg/L as Br	0.8 L	76,100 mg/L as Br	2.5 L	238,000 mg/L as Br

Automated ISCO samplers (Model 3700 with 24 1-liter teflon bottles) were deployed at the outlets from each tank and were programmed to collect 750 milliliter (mL) samples at 4-hour intervals, beginning at the time of initial tracer application (1,745 hours on April 19, 1999). The ISCO bottles were rinsed with source water and de-ionized water following each programmed cycle. The sampling frequency was reduced to an 8-hour interval on May 14, 1999. The ISCO samplers were removed on May 27, 1999, and grab samples were collected from the tank outlets for the remainder of the study. Grab samples were also collected at the ENR outflow pump station during the course of the experiment to verify that the discharge from the study tanks would not raise the background concentrations of lithium and/or bromide in discharges from the ENR to Water Catchment Area (WCA) 2.

A subset of 30 samples from each experiment was used to compare the two tracers. Bromide samples were analyzed using an Orion ion-specific probe (Model No. 96-35). Four standard solutions spanning the expected range of sample concentrations were prepared by diluting a 0.1 molar stock bromide solution. The electro-potential (millivolts [mV]) of each standard solution was measured using the ion-specific probe.

The measured electro-potentials of the samples were recorded, and concentrations were calculated using the regression equations. Lithium samples were chilled with ice for shipment to the laboratory. No other preservative was used for the lithium samples.

To assess the potential for the NaBr to be adsorbed to sediments and suspended particles, 1 liter of stock solution (approximately 350 mg/L as Br^-) was mixed with dry shellrock substrate and allowed to settle. The electro-potential was measured before, immediately after, and 6 hours after mixing. No change in electro-potential (-118 mV) was observed, which indicates that Br^- was not adsorbed by the shellrock. A similar study of the adsorption of LiCl to the shellrock will be conducted during the Test Cell tracer studies.

4.3.2.2 Results

The tracer study data were interpreted following the methods summarized by Kadlec and Knight (1996). The concentrations of the first samples from each tank were used as the background or starting concentrations. Appendix B presents the data collected for each experiment. Flows corresponding with each sample were interpolated from the flow records shown in Appendix B. Plots of tracer concentration versus time are also included in Appendix B.

Tracer Response Curves

Exhibits 4-8 through 4-10 show the tracer response curves (concentration versus time) for Tanks 7, 10, and 23, respectively. Each figure superimposes the response curves for the two tracers. The curves have been normalized by dividing the concentration of each sample by the maximum observed concentration.

Comparison of Exhibits 4-8 through 4-10 indicates that LiCl and NaBr showed nearly identical responses throughout the duration of the study. Tank 23 exhibited relatively lower Li concentrations throughout study.

Hydraulic Characteristics

Exhibits 4-11 through 4-13 summarize the hydraulic characteristics of Tanks 7, 10, and 23, as determined through this study.

The experimentally derived HRTs for each tank were longer than the nominal HRTs, which indicates unsteady flow conditions. The inlet valves to the three tanks frequently plugged with organic material, significantly reducing and sometimes completely stopping flow between site visits.

EXHIBIT 4-8
Porta-PSTA Tank 7 Normalized Tracer Response Curves

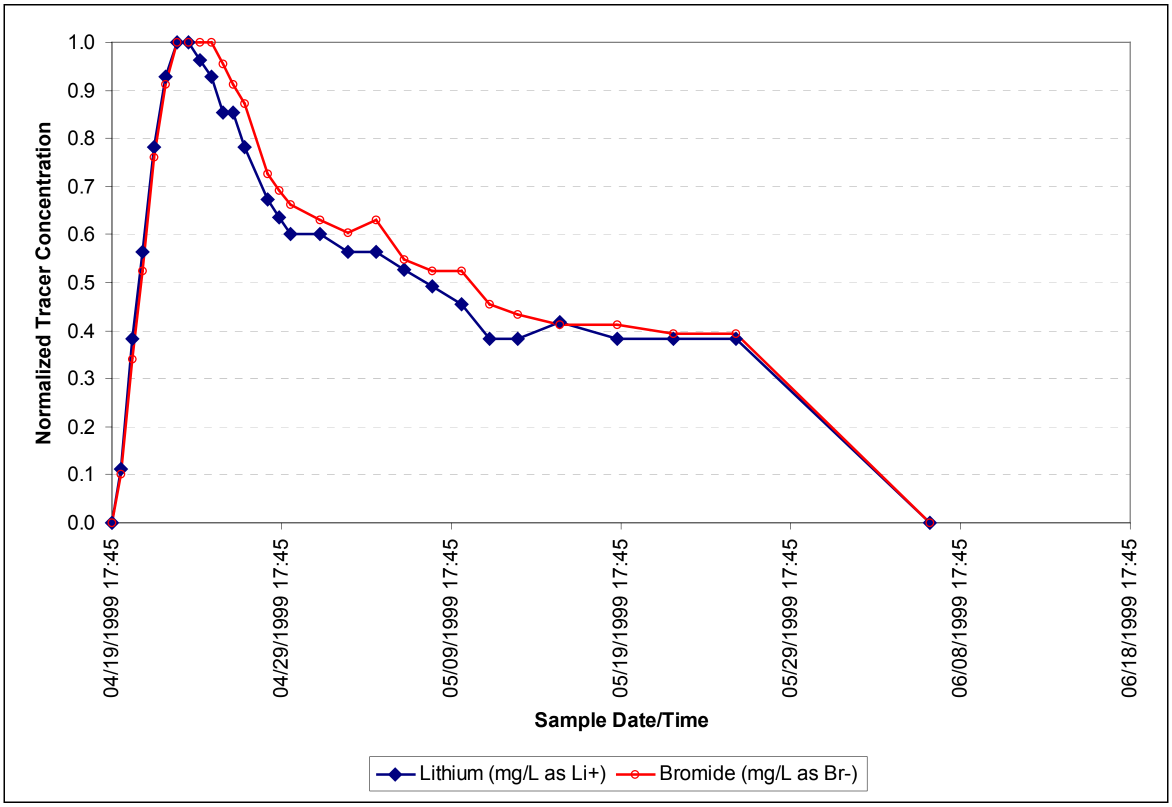


EXHIBIT 4-9
Porta-PSTA Tank 10 Normalized Tracer Response Curves

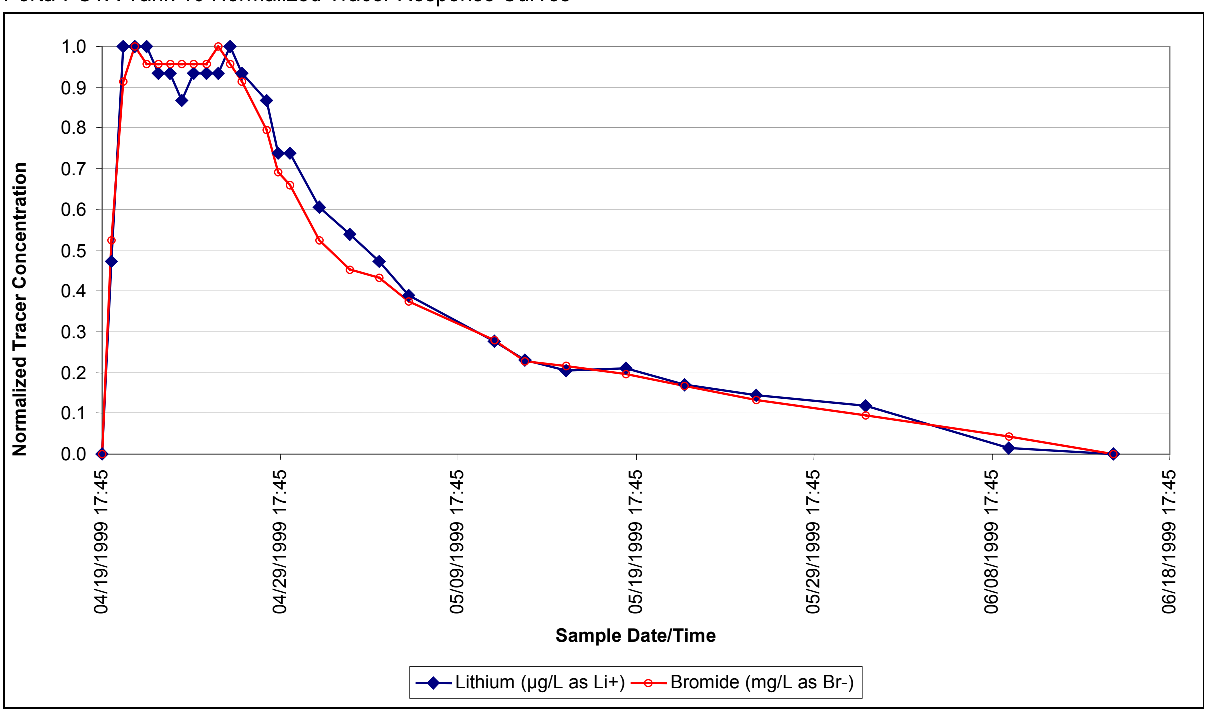


EXHIBIT 4-10
Porta-PSTA Tank 23 Normalized Tracer Response Curves

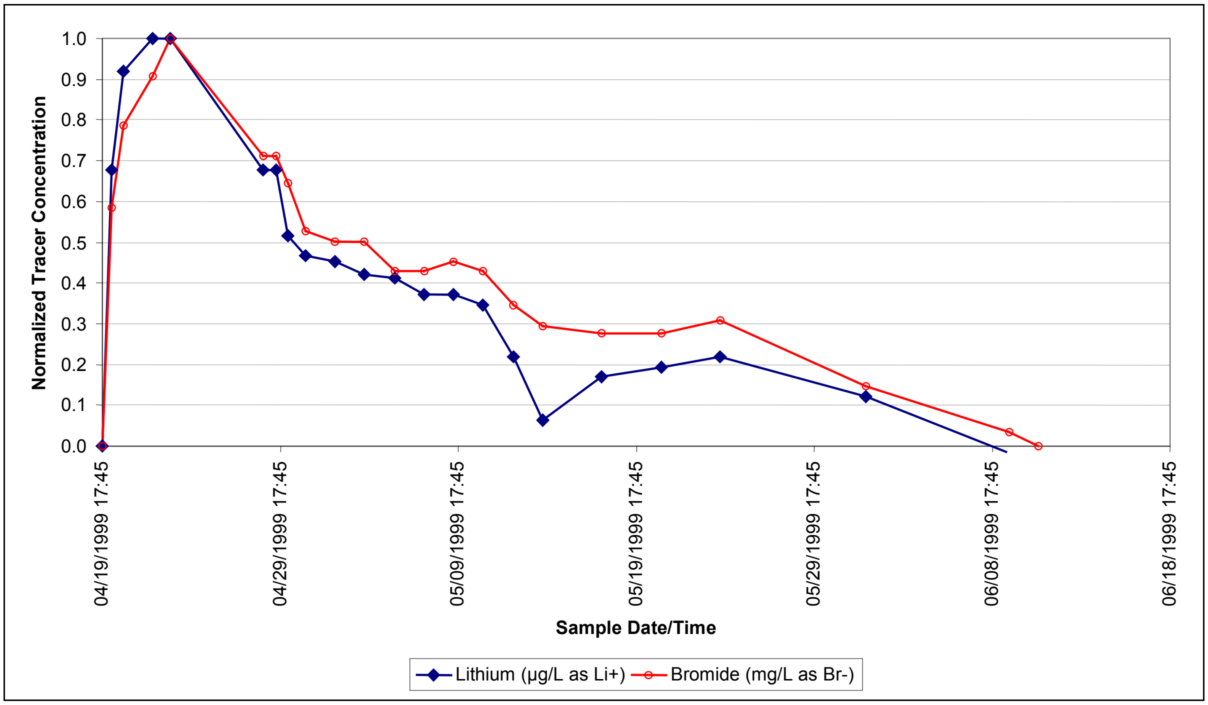


EXHIBIT 4-11
Tank 7 Combined Tracer Study Results

Parameter	Operating Conditions	LiCl Tracer	NaBr Tracer
Average Depth (m)	0.65	-	-
Average Volume (m^3)	3.88	-	-
Average Flow (m^3/d)	0.28	-	-
Nominal HRT (d)	14.0	-	-
Mean HRT, τ (d)	-	18.5	18.6
Variance, σ^2	-	159.1	155.0
Number of Tanks, N	-	2.15	2.22
Volumetric Efficiency (%)	-	132	132
Dimensionless Variance	-	0.46	0.45
Dispersion Number, D	-	0.34	0.33
Tracer Mass Recovery (percent)	-	83	110

EXHIBIT 4-12
Tank 10 Combined Tracer Study Results

Parameter	Operating Conditions	LiCl Tracer	NaBr Tracer
Average Depth (m)	0.36	-	-
Average Volume (m^3)	2.18	-	-
Average Flow (m^3/d)	0.27	-	-
Nominal HRT (d)	8.2	-	-
Mean HRT, τ (d)	-	14.6	14.7
Variance, σ^2	-	142.8	151.6
Number of Tanks, N	-	1.49	1.42
Volumetric Efficiency (%)	-	178	179
Dimensionless Variance	-	0.67	0.71
Dispersion Number, D	-	0.75	0.87
Tracer Mass Recovery	-	98	120

EXHIBIT 4-13
Tank 23 Combined Tracer Study Results

Parameter	Operating Conditions	LiCl Tracer	NaBr Tracer
Average Depth (m)	0.34	-	-
Average Volume (m^3)	6.14	-	-
Average Flow (m^3/d)	0.96	-	-
Nominal HRT (d)	6.4	-	-
Mean HRT, τ (d)	-	14.8	17.1
Variance, σ^2	-	150.7	166.8
Number of Tanks, N	-	1.45	1.75
Volumetric Efficiency (%)	-	228	266
Dimensionless Variance	-	0.69	0.57
Dispersion Number, D	-	0.81	0.50
Tracer Mass Recovery (percent)	-	75	87

The relatively low estimates of the tanks-in-series parameter (N) and high volumetric efficiencies further suggest that the inconsistent inflows retarded the movement of the tracers through the tanks. These parameters also indicate that the tanks are between well mixed and plug flow. The estimated tanks-in-series increased for tank 7 from approximately 1.2 to 2.2 between the first and second tracer studies.

4.3.2.3 Discussion

The testing procedures used for this study provide sufficient data to determine the hydraulic characteristics of the experimental systems at the PSTA research site. LiCl and NaBr produce similar results with deviations most likely attributable to analytical error.

Continuous or more infrequent inflow and outflow measurements will be conducted during future tracer studies to reduce variation between actual and nominal HRTs.

Elevated bromide concentrations were not detected at the ENR outflow pump station. Lithium samples from the ENR pump station were within the range of background conditions for the ENR.

Bromide adsorption was not observed for the shellrock substrate at the Porta-PSTA site. A lithium adsorption experiment will be conducted during the ENR Test Cell tracer studies.

NaBr can be used for future Porta-PSTA tracer studies. This approach offers distinct advantages over the use of LiCl in these mesocosms, including inexpensive onsite analysis of the samples and rapid data turn-around. Studies at the ENR Test Cells should use LiCl so that tracer spiking volumes can be efficiently managed by field personnel. For example, tracer studies at ENR Test Cell 13 will require only 7 liters of LiCl solution compared to 600 liters of NaBr solution.

4.4 Field Parameters

Field parameters (water temperature, pH, DO, percent saturation, salinity, TDS, and specific conductance) are measured weekly in the Porta-PSTAs at the inflow and outflow points, and monthly at one internal station. In addition, one recording data sonde unit is installed in the Head Tank to continuously document inflow conditions. Two recording data sonde units are routinely rotated between the mesocosms every 3 to 4 days to provide diel monthly records for each Test Cell each month.

Exhibit 4-14 summarizes the field parameter data as monthly averages available for each treatment for the first 6 months of operation. Appendix A provides monthly trend graphics for key parameters measured at the Porta-PSTAs.

Temperature: Average water temperatures in the Head Tank and the mesocoms increased during the study period, ranging between 24.69°C in April 1999 (Treatment 2) to 32.86°C in July 1999 (Treatment 11).

pH: Consistent pH measurements were recorded during the study period. For the three types of substrate, values averaged as follows: 7.42 SU (June 1999) to 7.50 SU (April 1999) in the Head Tank, 7.85 SU (Treatment 12 in July 1999) to 8.46 SU (Treatment 1 in May 1999) for the peat treatments (1, 3, 9, and 12), 8.17 SU (Treatment 11 in April 1999) to 8.82 SU (Treatment 2 in May 1999) for the shellrock treatments (2, 4, 5, 6, 10 and 11), and 8.13 SU (April 1999) to 9.09 SU (June 1999) for the sand treatments (7 and 8).

Dissolved Oxygen: Monthly average DO concentrations in the Head Tank ranged from 3.18 mg/L in July 1999 to 6.51 mg/L in May 1999. Monthly average DO concentrations for the sand treatments increased during the study period, with values ranging from 7.11 mg/L in April 1999 (Treatment 8) to 10.30 mg/L in June 1999 (Treatment 7). Peat treatments exhibited monthly average DO concentrations, ranging from 5.83 mg/L for Treatment 9 in July 1999 to 8.23 mg/L for Treatment 1 in May 1999. Monthly average DO concentrations for the shellrock treatments ranged

Exhibit 4-14

Monthly Average Field Measurements Collected from the Head Tank and the Twelve Porta-PSTA Treatments, April 1999 to July 1999

Parameter	Month	Head Tank	Treatment 1	2	3	4	5	6	7	8	9	10	11	12
Water Temperature (°C)	April-99	25.58	26.12	24.69	26.76	24.99	27.22	25.59	26.21	26.50	26.39	26.29	27.52	28.08
	May-99	26.67	26.44	26.43	26.11	26.27	27.39	25.33	26.86	27.09	27.48	27.52	27.28	28.71
	June-99	27.40	27.77	27.28	27.43	27.57	28.05	27.48	27.22	28.34	26.89	24.60	26.17	26.01
	July-99	29.28	30.20	29.41	30.63	29.91	31.05	29.76	31.12	30.70	29.98	30.31	32.86	32.45
pH (units)	April-99	7.50	8.23	8.49	8.16	8.60	8.27	8.57	8.18	8.13	8.13	8.27	8.17	8.04
	May-99	7.51	8.46	8.82	8.24	8.76	8.22	8.55	8.69	8.66	8.16	8.45	8.70	8.12
	June-99	7.42	8.36	8.29	8.23	8.60	8.24	8.41	9.09	8.83	8.09	8.34	8.47	8.13
	July-99	7.49	8.22	8.57	7.89	8.44	8.25	8.39	8.72	8.68	8.11	8.17	8.48	7.85
Conductivity (μmhos/cm)	April-99	973	1250	1282	1070	1192	1176	1301	1345	1151	1442	1460	1154	1130
	May-99	929	997	973	927	806	967	935	868	901	997	1025	827	1152
	June-99	823	762	855	668	740	772	719	684	826	936	830	1027	1180
	July-99	1042	866	839	926	900	936	846	846	819	888	871	888	962
Salinity (ppt)	April-99	0.51	0.66	0.68	0.55	0.63	0.62	0.69	--	--	--	--	--	--
	May-99	0.49	0.52	--	0.49	--	0.51	0.48	0.45	0.47	0.52	0.53	0.43	0.61
	June-99	0.43	0.39	0.45	0.33	0.38	0.40	0.37	0.35	0.43	0.49	--	0.54	0.64
	July-99	0.55	--	0.44	--	0.47	0.49	0.44	--	--	--	--	--	--
Total Dissolved Solids (g/L)	April-99	0.623	0.798	0.822	0.670	0.766	0.760	0.837	--	--	--	--	--	--
	May-99	0.595	0.642	--	0.595	--	0.628	0.594	0.553	0.573	0.634	0.651	0.527	0.746
	June-99	0.527	0.488	0.548	0.416	0.472	0.494	0.460	0.438	0.528	0.599	0.530	0.655	0.754
	July-99	0.667	0.554	0.537	0.593	0.576	0.599	0.541	0.542	0.524	0.568	0.557	0.569	0.616
Dissolved Oxygen Saturation (%)	April-99	57.9	89.5	123.9	89.6	123.6	105.4	119.6	--	--	--	--	--	--
	May-99	81.8	102.5	119.2	92.0	118.2	118.4	111.4	116.3	118.7	79.1	98.2	122.3	87.8
	June-99	64.0	93.4	113.7	92.2	115.1	100.1	113.1	130.4	120.2	78.6	97.1	116.7	86.7
	July-99	42.0	97.7	114.3	94.6	113.5	111.2	105.1	133.4	129.4	77.3	88.2	124.7	86.1
Dissolved Oxygen (mg/L)	April-99	4.72	7.06	10.40	7.32	10.05	8.39	9.87	7.40	7.11	6.72	7.71	7.79	7.09
	May-99	6.51	8.23	9.88	7.47	9.69	9.29	8.87	9.21	9.39	6.23	7.71	9.53	6.64
	June-99	5.05	7.18	8.96	7.19	9.05	7.84	8.91	10.30	9.32	6.26	8.68	9.38	7.00
	July-99	3.18	7.25	8.46	6.96	8.60	8.24	8.01	9.86	9.61	5.83	6.63	8.94	6.20

from 6.63 mg/L (Treatment 10 in July 1999) to 10.40 mg/L (Treatment 2 in April 1999).

Conductivity: Monthly average conductivity measurements for the Head Tank ranged from 823 µmhos/cm to 1,042 µmhos/cm during the study period. Conductivity measurements in mesocosms exhibited an overall decreasing trend over the study period with averages ranging from 1,460 µmhos/cm in April 1999 (Treatment 12) to 668 µmhos/cm in June 1999 (Treatment 3).

Salinity: Salinity readings followed the identical decreasing trend as observed with the conductivity measurements. Average monthly values ranged from 0.69 ppt in Treatment 6 (April 1999) to 0.33 ppt in Treatment 3 (June 1999). Monthly average salinity values in the Head Tank ranged from 0.43 ppt in June 1999 to 0.55 ppt in July 1999.

Total Dissolved Solids: Monthly average TDS concentrations also decreased during the study period, with values ranging from 0.837 g/L in April 1999 (Treatment 6) to 0.416 g/L in June 1999 (Treatment 3). Monthly average TDS concentrations in the Head Tank ranged from 0.527 g/L (June 1999) to 0.667 g/L (July 1999).

4.5 Water Quality Data

Water quality samples were collected from the Head Tank and at different locations within each mesocosm at varying frequencies in accordance with the PSTA Research Plan. Water quality monitoring at the Porta-PSTAs parallels monitoring conducted at the ENR South Test Cells as described under Section 3.4.

Monthly average values for water quality data collected from April 1999 to July 1999 at the Head Tank and the Porta-PSTAs are presented in Exhibit 4-15, and are summarized below. Appendix A provides monthly trend graphics for key parameters measured at the Porta-PSTAs.

Total Phosphorus: Average monthly inflow TP concentrations generally decreased since startup. Inflow TP was between 0.036 and 0.045 mg/L in April and declined to 0.013 mg/L in July. This decrease in TP inflow concentration was the result of lower concentrations of both TPP and TDP fractions. Outflow TP concentrations were initially high and have decreased over time in all of the Porta-PSTA treatments. All outflow TP concentrations in July were in the range of 0.013 to 0.018 mg/L. Detailed TP trend charts for all treatments are provided in Exhibits 4-16 through 4-27, and in Appendix A.

Total Nitrogen: TN levels in all 12 treatments decreased as water passed through each cell. Monthly inflow TN concentrations ranged from 0.61 mg/L in May 1999 (Treatment 5) to 1.48 mg/L in April 1999 (All Treatments). Monthly outflow TN concentration followed a similar pattern, with values ranging from 1.73 mg/L in February 1999 to 0.44 mg/L in July 1999 (Treatment 7).

Exhibit 4-15

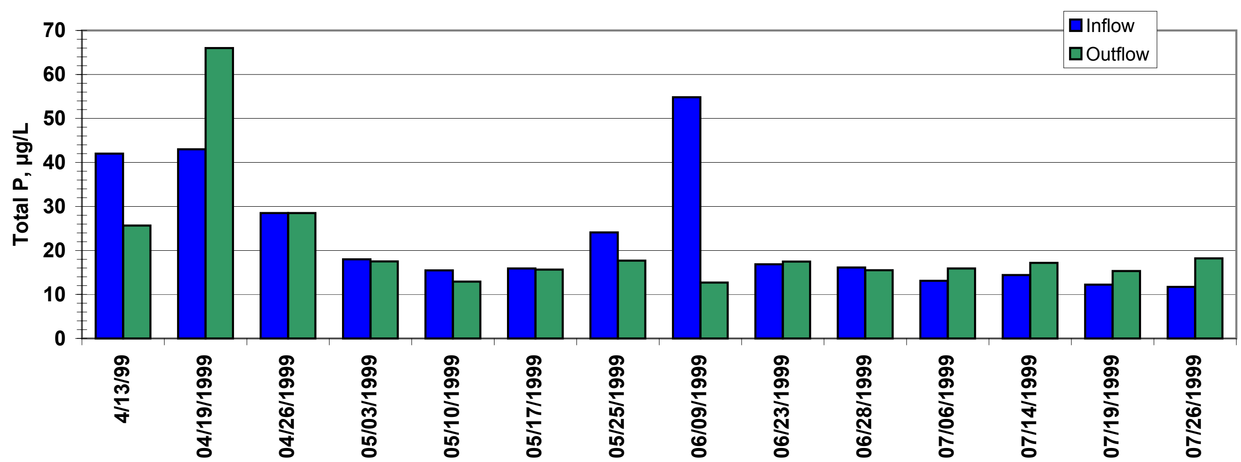
Monthly Average Values of Water Quality Data Collected at the Porta-PSTA Head Tank and Twelve Porta-PSTA Treatments, April 1999 to July 1999

		Treatment																							
		1 (Peat)		2 (Shellrock)		3 (Peat)		4 (Shellrock)		5 (Shellrock)		6 (Shellrock)		7 (Sand)		8 (Sand)		9 (Peat)		10 (Shellrock)		11 (Shellrock)		12 (Peat)	
Parameter	**Month**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**
Total Phosphorus, as P (mg/L)	April-99	0.038	0.038	0.045	0.041	0.038	0.029	0.039	0.038	0.039	0.033	0.038	0.037	0.040	0.062	0.037	0.047	0.041	0.028	0.036	0.027	0.040	0.063	0.037	0.037
	May-99	0.018	0.016	0.019	0.022	0.018	0.018	0.019	0.022	0.019	0.021	0.019	0.029	0.019	0.016	0.019	0.022	0.019	0.016	0.019	0.015	0.020	0.035	0.019	0.023
	June-99	0.029	0.015	0.035	0.021	0.028	0.015	0.028	0.019	0.030	0.014	0.029	0.015	0.029	0.027	0.029	0.019	0.029	0.012	0.029	0.020	0.027	0.018	0.027	0.018
	July-99	0.013	0.017	0.013	0.013	0.013	0.014	0.013	0.015	0.013	0.017	0.013	0.013	0.013	0.013	0.013	0.015	0.013	0.014	0.013	0.014	0.013	0.016	0.013	0.018
Total Particulate Phosphorus (mg/L)	April-99	0.018	0.023	0.025	0.026	0.018	0.014	0.019	0.025	0.019	0.017	0.018	0.025	0.020	0.044	0.017	0.031	0.021	0.012	0.017	0.013	0.020	0.045	0.017	0.022
	May-99	0.003	0.004	0.005	0.012	0.005	0.008	0.004	0.012	0.005	0.011	0.005	0.018	0.006	0.004	0.006	0.010	0.006	0.004	0.007	0.004	0.006	0.024	0.006	0.011
	June-99	0.018	0.006	0.024	0.010	0.016	0.006	0.017	0.011	0.018	0.005	0.018	0.007	0.019	0.019	0.018	0.011	0.019	0.003	0.018	0.011	0.016	0.008	0.016	0.009
	July-99	0.004	0.009	0.005	0.006	0.004	0.007	0.005	0.007	0.005	0.010	0.005	0.007	0.004	0.006	0.005	0.009	0.004	0.007	0.005	0.007	0.004	0.000	0.004	0.009
Total Dissolved Phosphorus (mg/L)	April-99	0.020	0.015	0.020	0.014	0.020	0.015	0.020	0.013	0.020	0.016	0.020	0.012	0.020	0.018	0.020	0.016	0.020	0.016	0.020	0.015	0.020	0.018	0.020	0.015
	May-99	0.015	0.011	0.014	0.010	0.014	0.010	0.014	0.010	0.013	0.010	0.014	0.011	0.013	0.012	0.013	0.012	0.013	0.012	0.013	0.011	0.014	0.011	0.013	0.012
	June-99	0.011	0.009	0.011	0.011	0.012	0.009	0.011	0.009	0.011	0.009	0.011	0.008	0.010	0.008	0.011	0.008	0.010	0.009	0.011	0.009	0.012	0.010	0.011	0.009
	July-99	0.009	0.007	0.008	0.007	0.009	0.007	0.008	0.007	0.008	0.007	0.008	0.007	0.009	0.007	0.008	0.007	0.008	0.007	0.008	0.007	0.009	0.019	0.008	0.009
Soluble Reactive Phosphorus (mg/L)	April-99	0.005	0.004	0.005	0.005	0.005	0.003	0.005	0.003	0.005	0.003	0.005	0.003	0.005	0.005	0.005	0.003	0.006	0.004	0.005	0.005	0.006	0.003	0.005	0.003
	May-99	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.002
	June-99	0.003	0.002	0.003	0.005	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.002	0.003	0.002
	July-99	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.003
Dissolved Organic Phosphorus (mg/L)	April-99	0.015	0.011	0.015	0.009	0.015	0.013	0.015	0.010	0.015	0.013	0.015	0.010	0.015	0.013	0.015	0.013	0.014	0.012	0.014	0.010	0.014	0.014	0.014	0.012
	May-99	0.012	0.009	0.011	0.007	0.010	0.008	0.011	0.007	0.010	0.008	0.011	0.007	0.009	0.009	0.010	0.009	0.010	0.009	0.009	0.007	0.011	0.008	0.009	0.010
	June-99	0.008	0.007	0.007	0.007	0.009	0.007	0.008	0.006	0.008	0.007	0.008	0.006	0.007	0.006	0.008	0.006	0.007	0.006	0.008	0.007	0.009	0.008	0.009	0.007
	July-99	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.005	0.005	0.005	0.004	0.005	0.005	0.005	0.005	0.005	0.016	0.005	0.006
Total Nitrogen, as N (mg/L)	April-99	1.48	1.04	1.48	0.92	1.48	1.30	1.48	0.99	1.48	0.91	1.48	1.43	1.48	1.73	1.48	1.34	1.48	--	1.48	1.49	1.48	1.38	1.48	1.59
	May-99	0.83	1.07	0.95	1.09	0.82	1.00	0.88	1.46	0.61	0.91	0.92	1.19	0.92	0.97	0.91	0.92	0.90	0.84	0.82	1.00	0.83	0.90	0.94	1.02
	June-99	0.89	0.45	0.89	0.72	0.89	0.46	0.89	0.65	0.89	0.47	0.89	0.57	0.89	0.57	0.89	0.53	0.89	0.80	0.89	0.82	0.89	0.81	0.89	0.80
	July-99	1.09	0.50	1.09	0.65	1.09	0.46	1.09	0.49	1.09	0.60	1.09	0.46	1.09	0.44	1.09	0.63	1.09	0.80	1.09	0.46	1.09	1.00	1.09	0.50
Total Kjeldahl Nitrogen, as N (mg/L)	April-99	1.41	1.04	1.41	0.92	1.41	1.20	1.41	0.95	1.41	0.91	1.41	1.33	1.41	1.55	1.41	1.34	1.41	1.60	1.41	1.49	1.41	1.38	1.41	1.59
	May-99	0.73	1.07	0.85	1.09	0.72	0.97	0.78	1.46	0.51	0.91	0.81	1.19	0.83	0.97	0.84	0.92	0.83	0.78	0.75	1.00	0.76	0.90	0.87	1.02
	June-99	0.83	0.45	0.83	0.55	0.83	0.46	0.83	0.55	0.83	0.47	0.83	0.55	0.83	0.57	0.83	0.53	0.83	0.80	0.83	0.82	0.83	0.81	0.83	0.80
	July-99	0.94	0.50	0.94	0.65	0.94	0.46	0.94	0.49	0.94	0.60	0.94	0.46	0.94	0.44	0.94	0.63	0.94	0.80	0.94	0.46	0.94	1.00	0.94	0.50
Nitrate/Nitrite, as N (mg/L)	April-99	0.07	0.03	0.07	0.03	0.07	0.04	0.07	0.05	0.07	0.03	0.07	0.11	0.07	0.18	0.07	0.03	0.07	--	0.07	0.03	0.07	0.03	0.07	0.03
	May-99	0.09	0.03	0.10	0.03	0.10	0.03	0.10	0.03	0.11	0.03	0.11	0.03	0.09	0.03	0.07	0.03	0.07	0.06	0.08	0.03	0.07	0.03	0.08	0.03
	June-99	0.05	0.03	0.05	0.15	0.05	0.03	0.05	0.12	0.05	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05	0.03
	July-99	0.08	0.03	0.08	0.03	0.08	0.03	0.08	0.03	0.08	0.03	0.08	0.03	0.08	0.03	0.08	0.03	0.08	0.03	0.08	0.03	0.08	0.03	0.08	0.03
Ammonia, as NH3 (mg/L)	April-99	0.02	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	May-99	0.02	0.02	0.08	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	June-99	0.02	0.02	0.02	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.02	0.09	0.02	0.02	0.02	0.02
	July-99	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Organic Nitrogen (mg/L)	April-99	1.39	1.00	1.39	0.90	1.39	1.18	1.39	0.93	1.39	0.89	1.39	1.28	1.39	1.53	1.39	1.32	1.39	1.58	1.39	1.47	1.39	1.36	1.39	1.57
	May-99	0.71	1.05	0.76	1.07	0.70	0.95	0.76	1.43	0.49	0.89	0.79	1.17	0.81	0.95	0.82	0.90	0.81	0.76	0.73	0.98	0.74	0.88	0.85	1.00
	June-99	0.81	0.43	0.81	0.50	0.81	0.44	0.81	0.53	0.81	0.45	0.81	0.53	0.81	0.55	0.81	0.51	0.81	0.76	0.81	0.73	0.81	0.79	0.81	0.78
	July-99	0.92	0.48	0.92	0.63	0.92	0.44	0.92	0.47	0.92	0.58	0.92	0.44	0.92	0.42	0.92	0.61	0.92	0.78	0.92	0.44	0.92	0.98	0.92	0.48
TOC (mg/L)	April-99	23.00	33.45	23.00	34.05	23.00	32.60	23.00	35.07	23.00	29.67	23.00	37.53	23.00	29.60	23.00	28.60	23.00	30.00	23.00	32.70	23.00	28.80	23.00	29.70
	May-99	22.07	27.00	22.40	30.15	21.63	26.03	22.23	29.73	21.87	24.67	21.77	33.67	21.40	23.90	21.20	24.70	21.20	23.70	21.50	26.90	21.10	23.40	21.20	23.60
	June-99	18.40	19.97	18.40	19.90	18.40	20.73	18.40	19.83	18.40	19.73	18.40	19.33	18.40	21.80	18.40	21.90	18.40	18.70	18.40	19.40	18.40	18.80	18.40	18.60
	July-99	32.00	28.27	32.00	26.37	32.00	30.60	32.00	32.73	32.00	29.17	32.00	30.77	32.00	35.50	32.00	26.50	32.00	27.40	32.00	29.90	32.00	32.10	32.00	31.50
TSS (mg/L)	April-99	<4.0	10.0	<4.0	8.0	<4.0	5.3	<4.0	6.7	<4.0	4.7	<4.0	4.7	<4.0	8.0	<4.0	<4.0	<4.0	18.0	<4.0	8.0	<4.0	20.0	<4.0	24.0
	May-99	4.0	5.3	<4.0	13.0	<4.0	5.3	<4.0	5.0	6.0	6.0	<4.0	3.3	9.0	2.0	4.0	12.0	<4.0	10.0	14.0	32.0	4.0	10.0	6.0	14.0
	June-99	<4.0	4.0	<4.0	10.7	<4.0	6.7	<4.0	15.0	<4.0	14.0	<4.0	12.7	<4.0	2.0	<4.0	<4.0	<4.0	<4.0	<4.0	8.0	<4.0	6.0	<4.0	<4.0
	July-99	4.0	6.7	4.0	4.7	4.0	6.7	4.0	8.7	4.0	2.7	4.0	6.7	4.0	4.0	4.0	8.0	4.0	6.0	4.0	<4.0	4.0	6.0	4.0	4.0
Calcium (mg/L)	April-99	38.10	46.05	38.10	36.45	38.10	44.77	38.10	34.10	38.10	41.77	38.10	32.93	38.10	44.00	38.10	43.00	38.10	52.60	38.10	40.40	38.10	42.00	38.10	49.40
	May-99	39.50	36.90	40.40	28.40	38.73	35.47	40.43	27.50	38.27	34.93	39.90	27.67	36.80	30.00	36.70	29.10	36.80	44.30	36.70	36.30	37.60	29.80	37.30	37.30
	June-99	47.20	39.27	47.20	30.03	47.20	45.33	47.20	32.17	47.20	37.13	47.20	39.10	47.20	27.50	47.20	34.40	47.20	38.50	47.20	36.50	47.20	30.50	47.20	46.60
	July-99	54.00	46.67	54.00	36.00	54.00	55.33	54.00	37.77	54.00	41.33	54.00	42.30	54.00	31.80	54.00	31.00	54.00	52.00	54.00	46.70	54.00	40.00	54.00	58.00
Alkalinity (mg/L)	April-99	170.0	199.0	170.0	173.0	170.0	199.3	170.0	156.0	170.0	182.7	170.0	147.3	170.0	209.0	170.0	198.0	170.0	230.0	170.0	206.0	170.0	181.0	170.0	194.0
	May-99	164.3	164.7	166.5	128.5	165.0	141.0	164.0	112.3	167.7	142.0	167.0	113.0	160.0	145.0	163.0	147.0	165.0	189.0	162.0	167.0	161.0	134.0	163.0	167.0
	June-99	169.0	153.7	169.0	120.3	169.0	156.7	169.0	120.7	169.0	133.7	169.0	132.3	169.0	119.0	169.0	126.0	169.0	153.0	169.0	132.0	169.0	120.0	169.0	169.0
	July-99	220.0	188.7	220.0	153.7	220.0	215.0	220.0	150.0	220.0	180.3	220.0	170.7	220.0	147.0	220.0	148.0	220.0	194.0	220.0	180.0	220.0	163.0	220.0	220.0

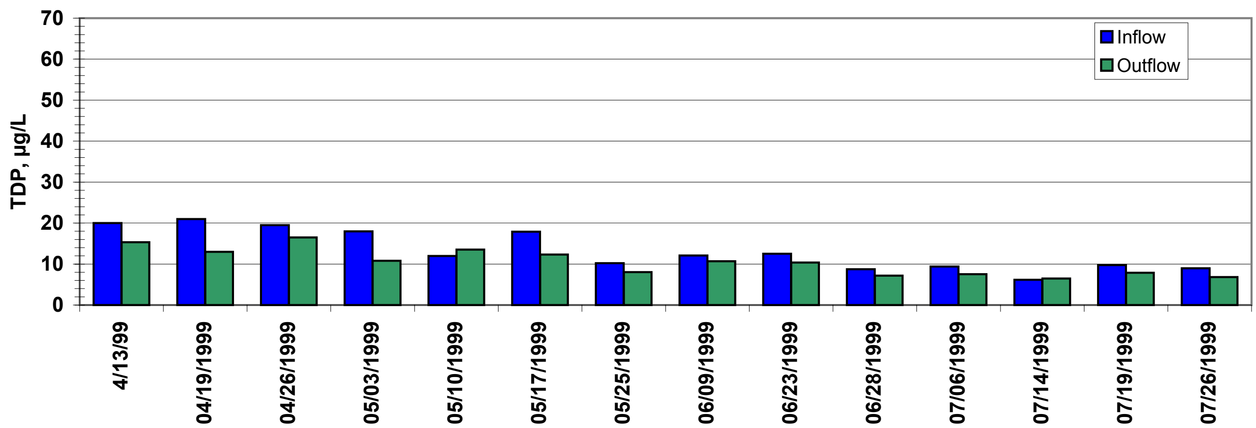
Notes:

For values reported as below the method detection limit, one-half the method detection limit was used in the calculation of average values.

TOTAL PHOSPHORUS



TOTAL DISSOLVED PHOSPHORUS



TOTAL PARTICULATE PHOSPHORUS

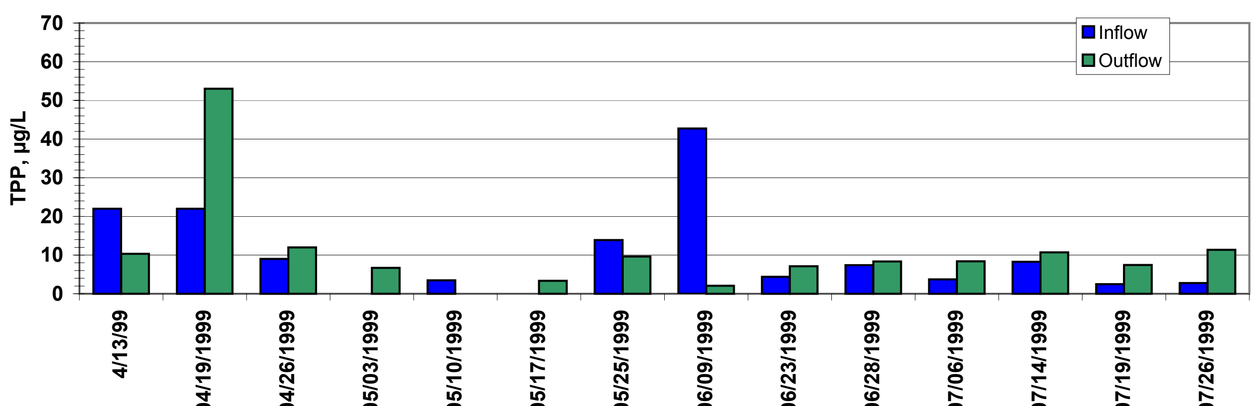
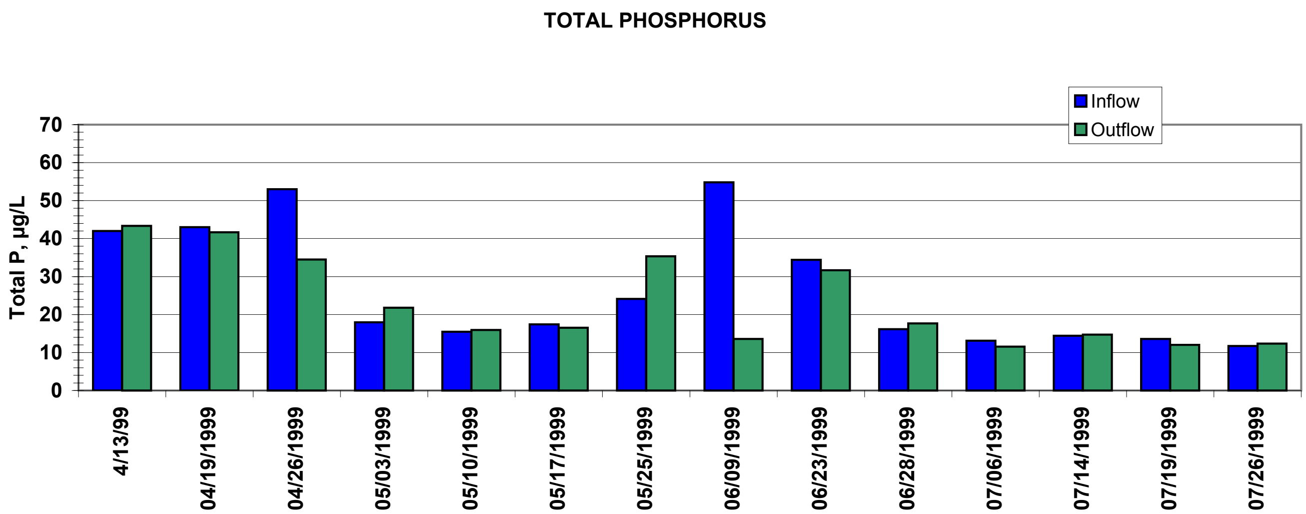
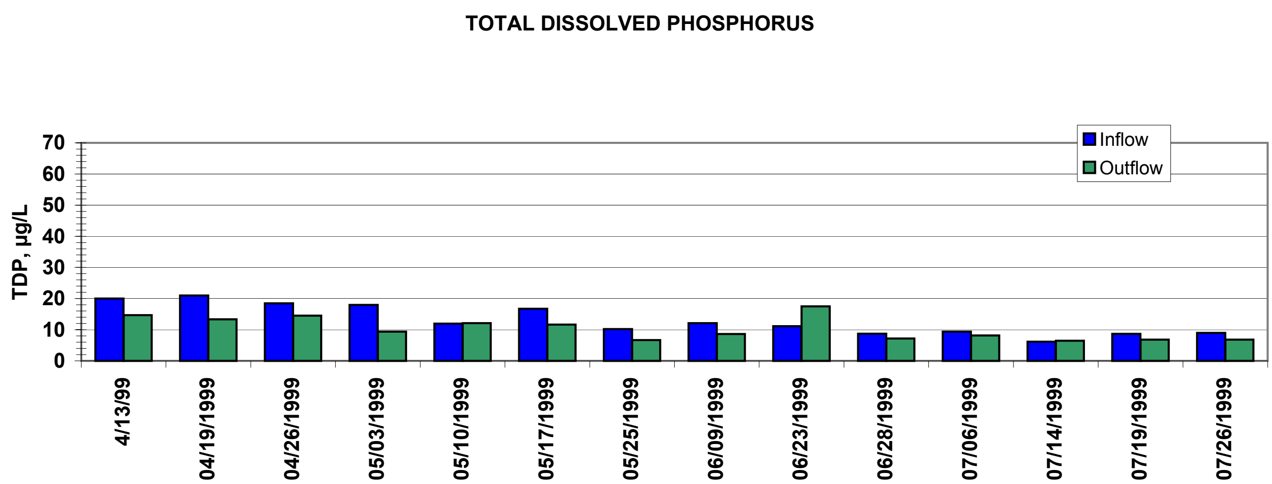


Exhibit 4-16
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 1, April - July 1999





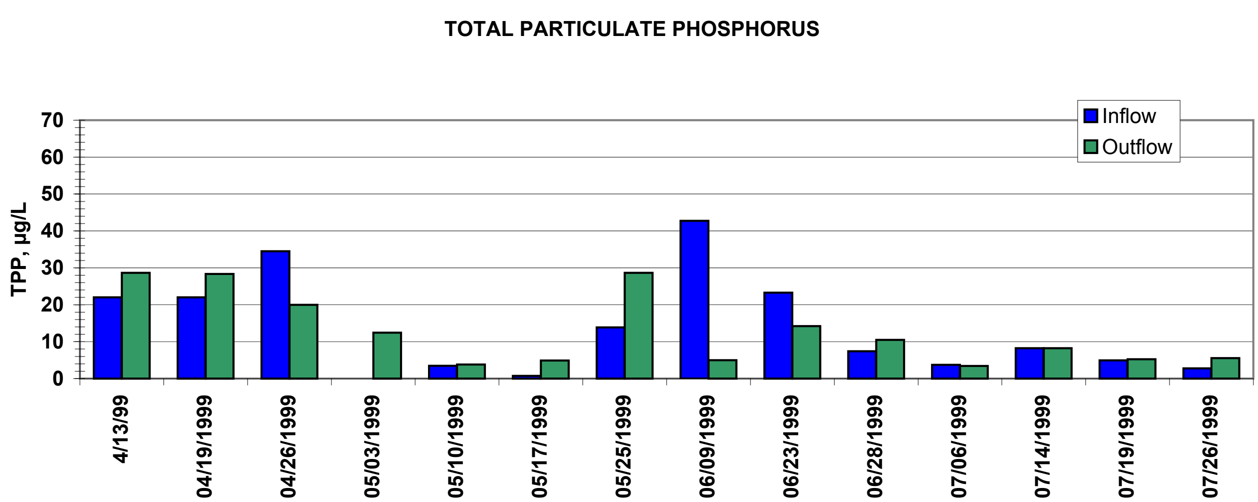
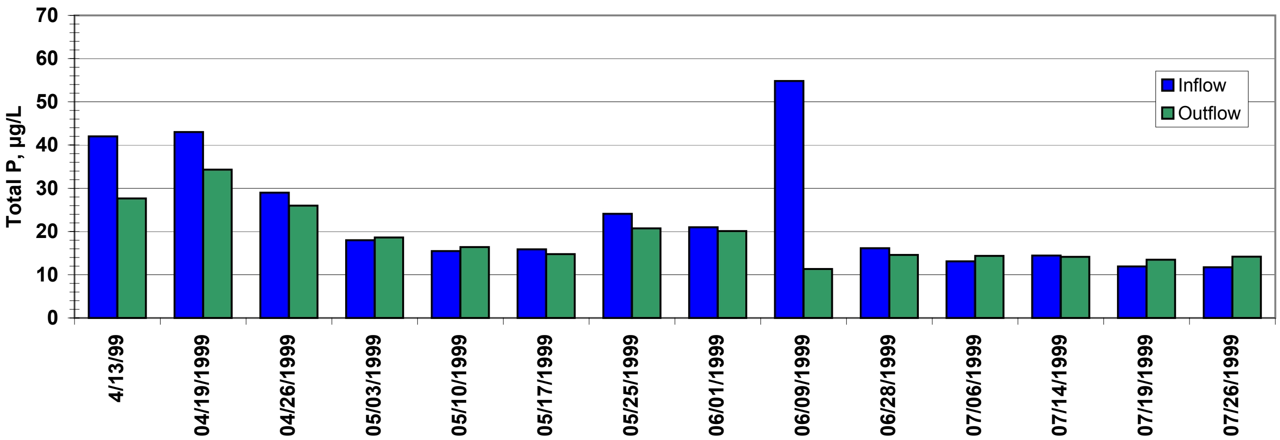
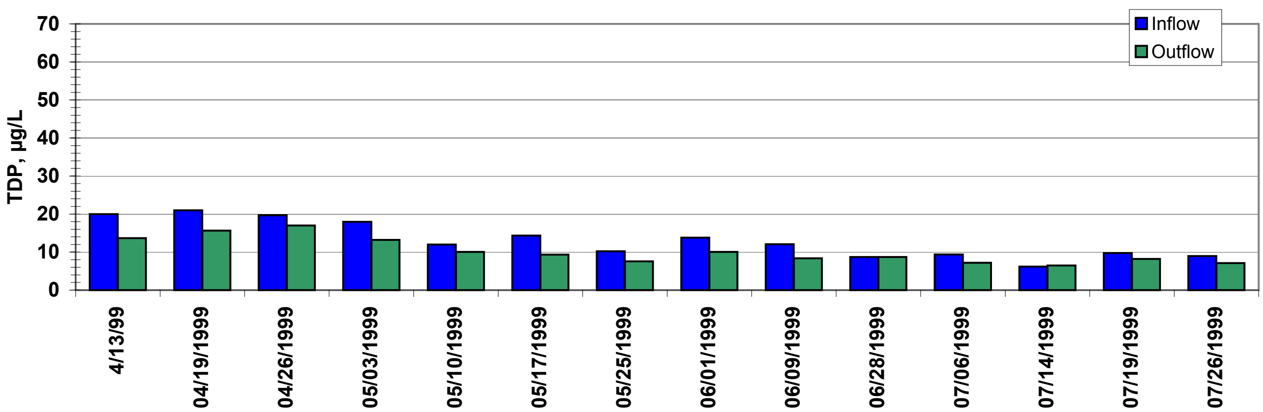


Exhibit 4-17
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 2, April - July 1999

TOTAL PHOSPHORUS



TOTAL DISSOLVED PHOSPHORUS



TOTAL PARTICULATE PHOSPHORUS

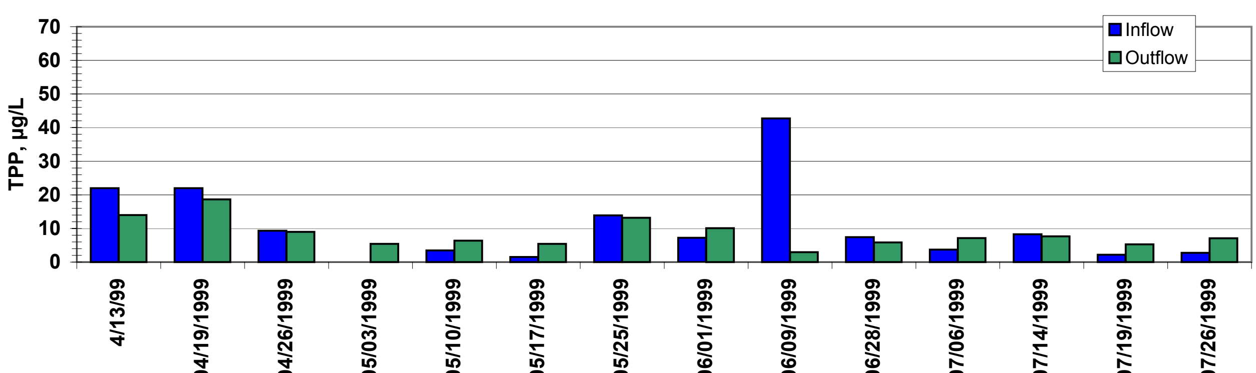
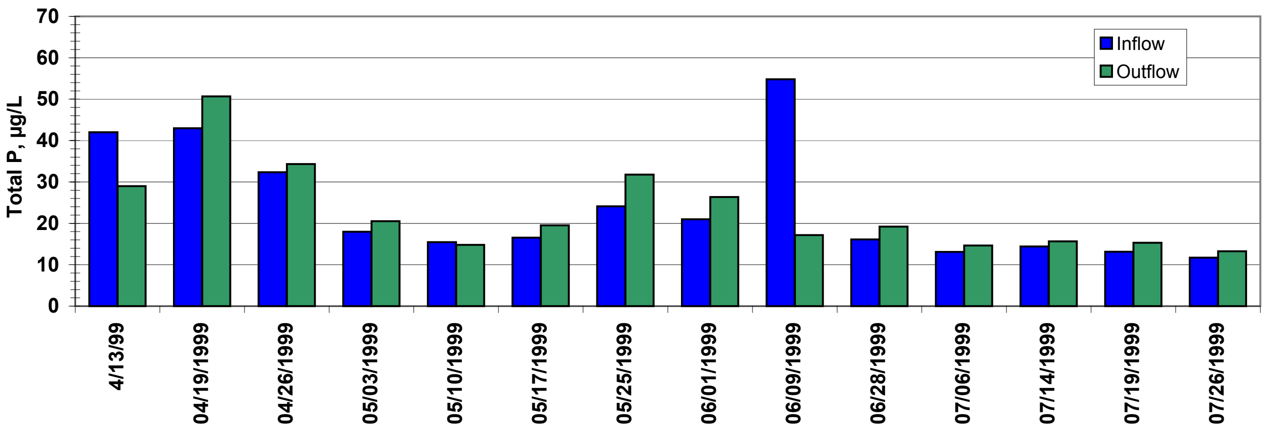
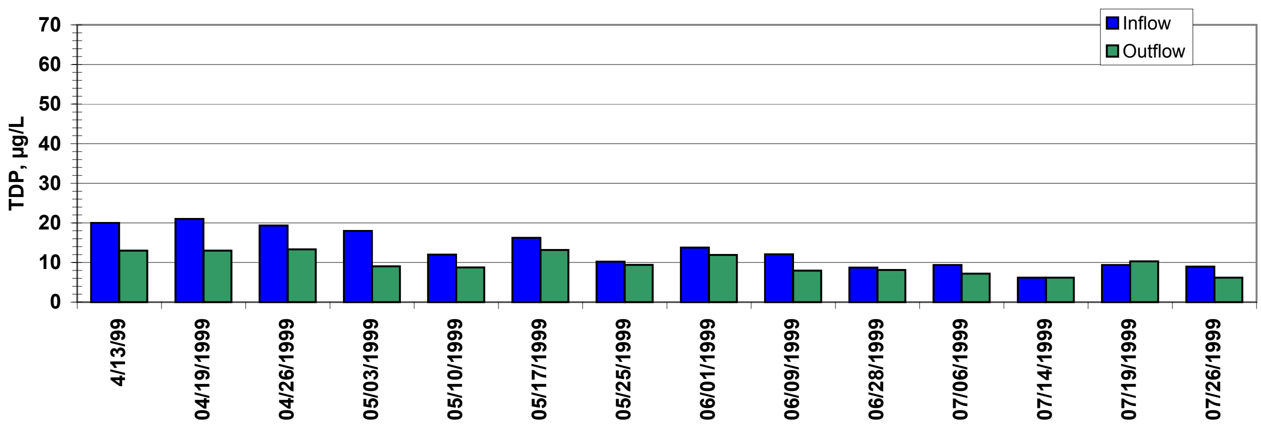


Exhibit 4-18
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 3, April - July 1999

TOTAL PHOSPHORUS



TOTAL DISSOLVED PHOSPHORUS



TOTAL PARTICULATE PHOSPHORUS

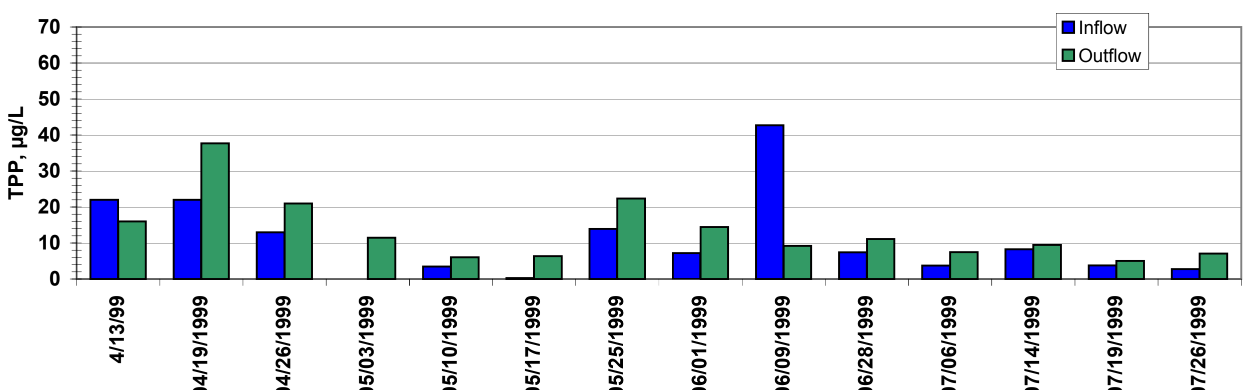
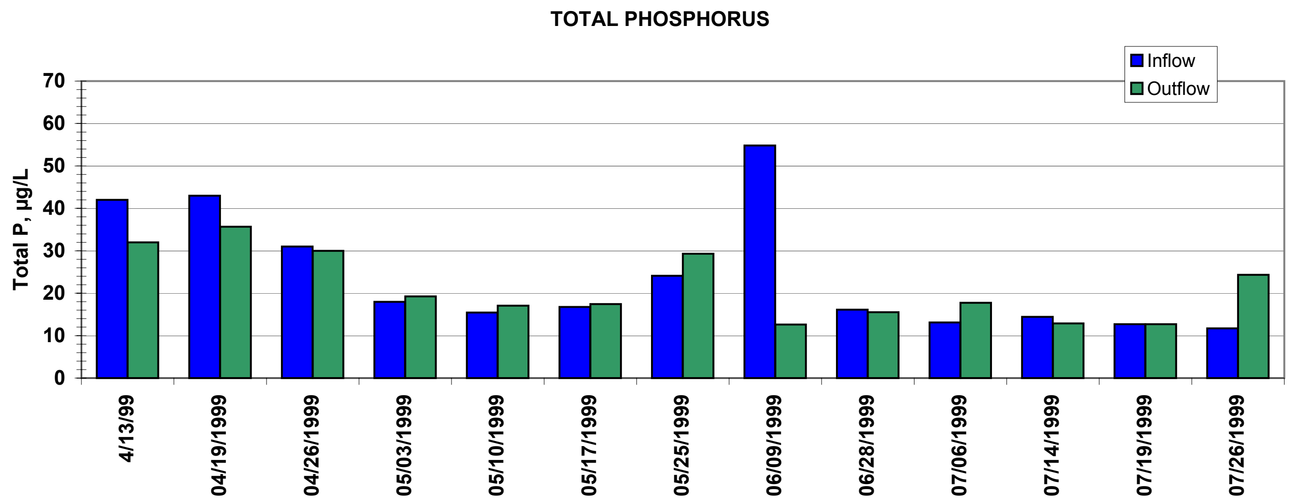
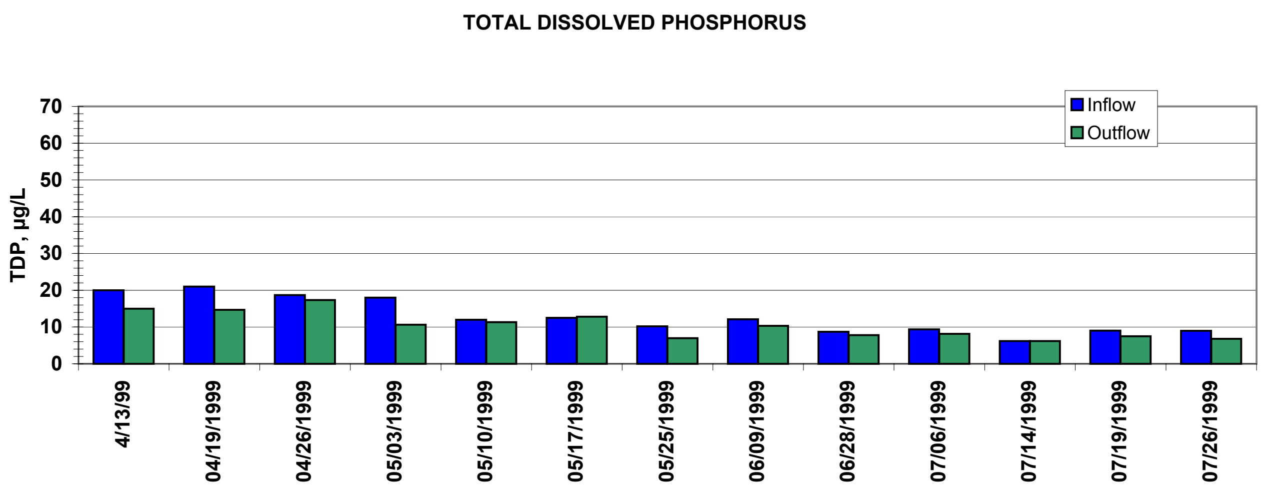


Exhibit 4-19
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 4, April - July 1999





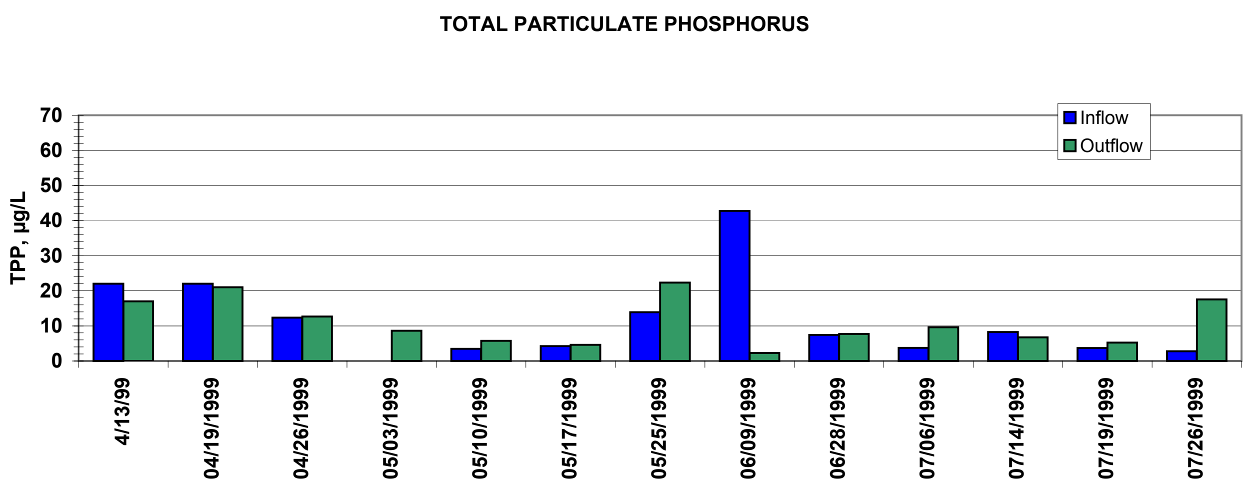
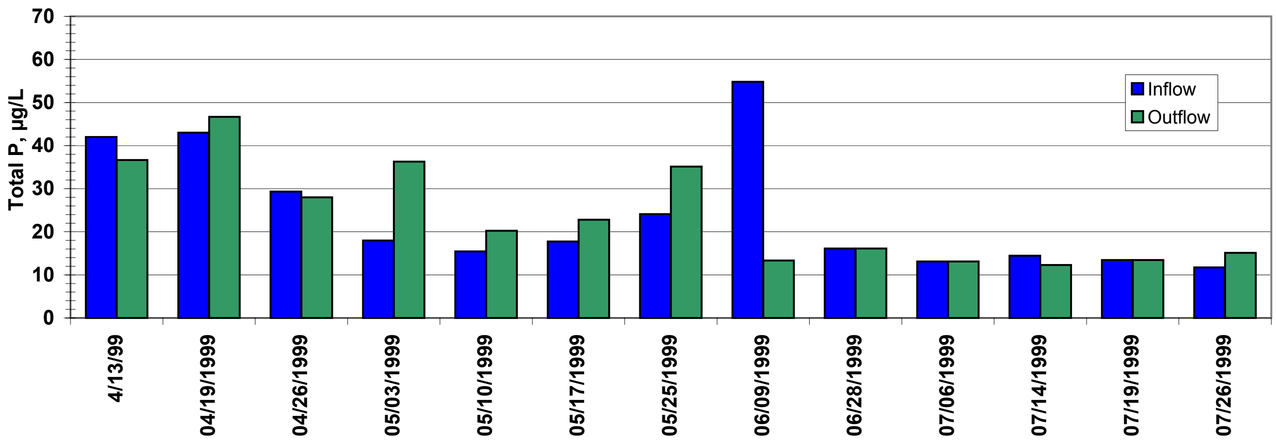
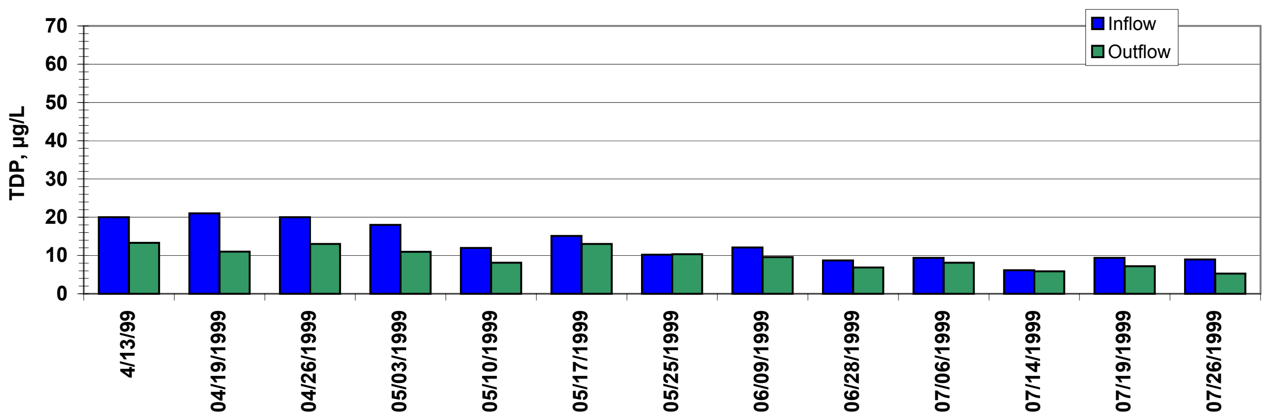


Exhibit 4-20
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 5, April - July 1999

TOTAL PHOSPHORUS



TOTAL DISSOLVED PHOSPHORUS



TOTAL PARTICULATE PHOSPHORUS

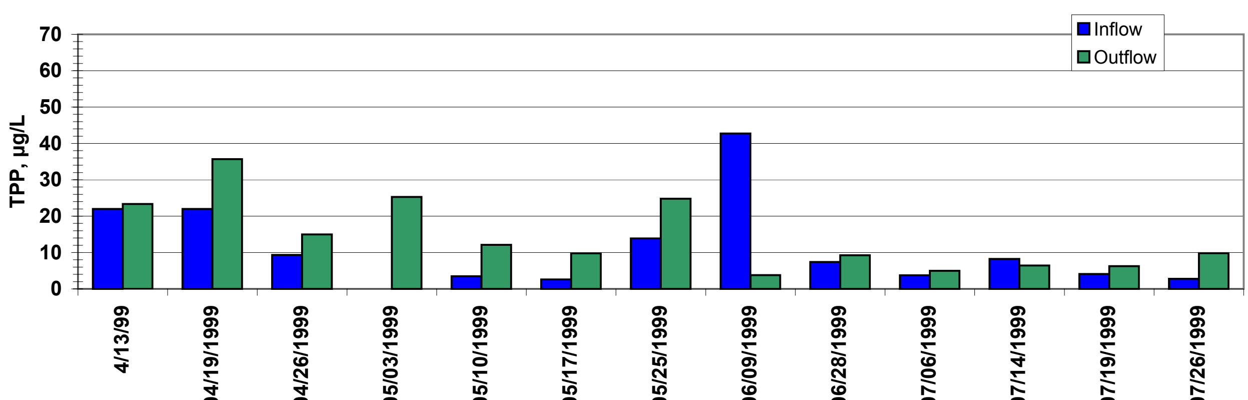
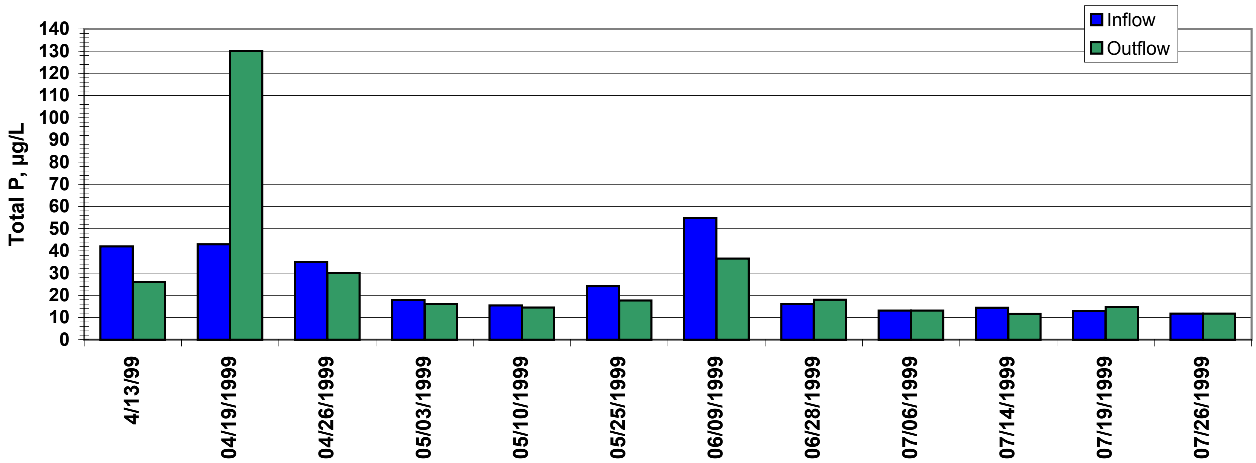
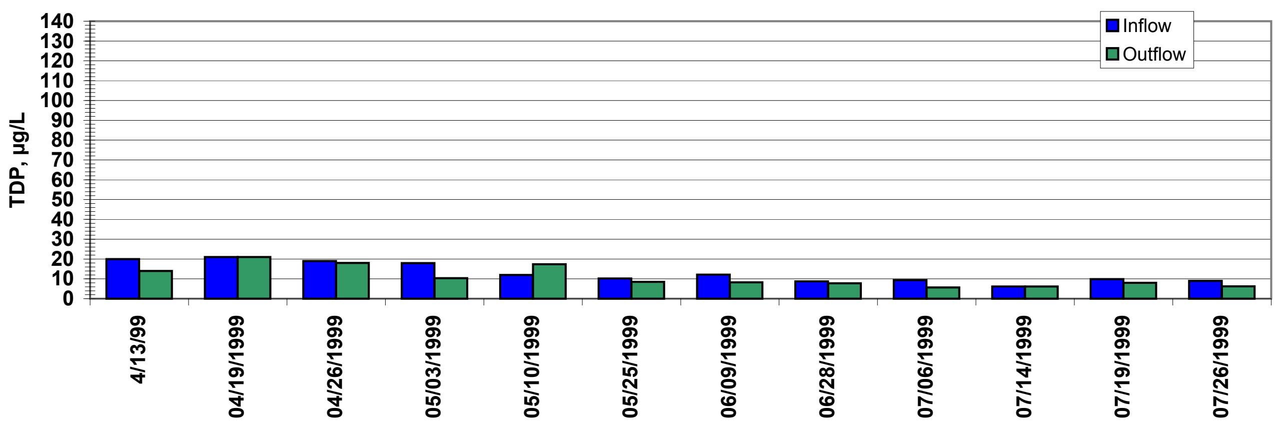


Exhibit 4-21
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 6, April - July 1999

TOTAL PHOSPHORUS



TOTAL DISSOLVED PHOSPHORUS



TOTAL PARTICULATE PHOSPHORUS

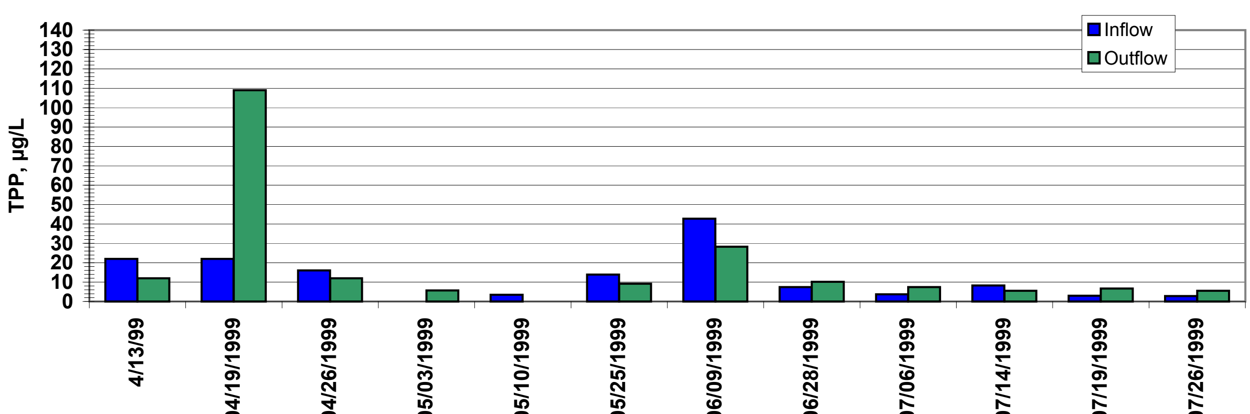
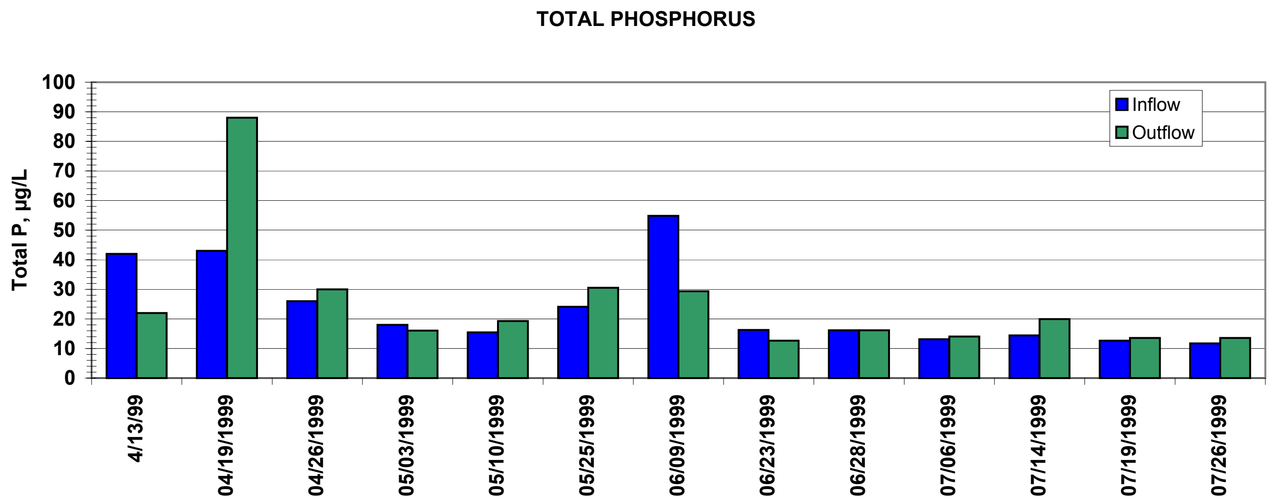
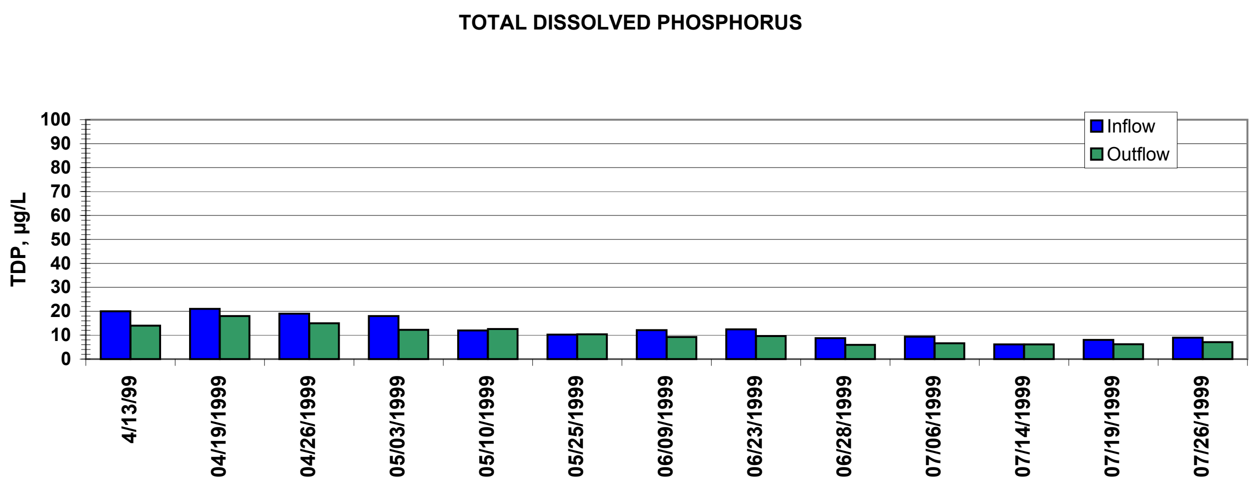


Exhibit 4-22
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 7, April - July 1999





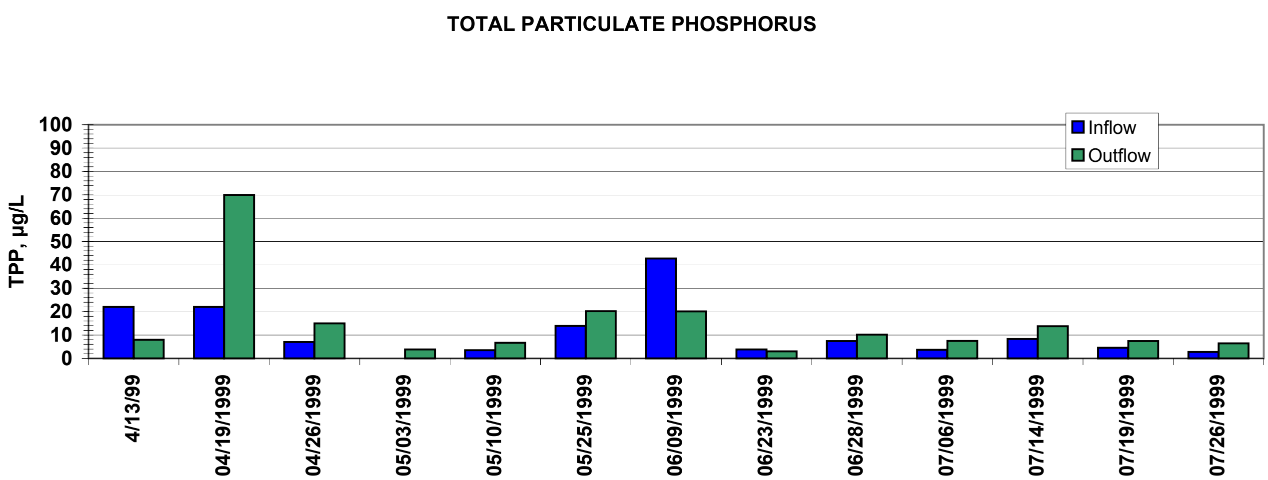
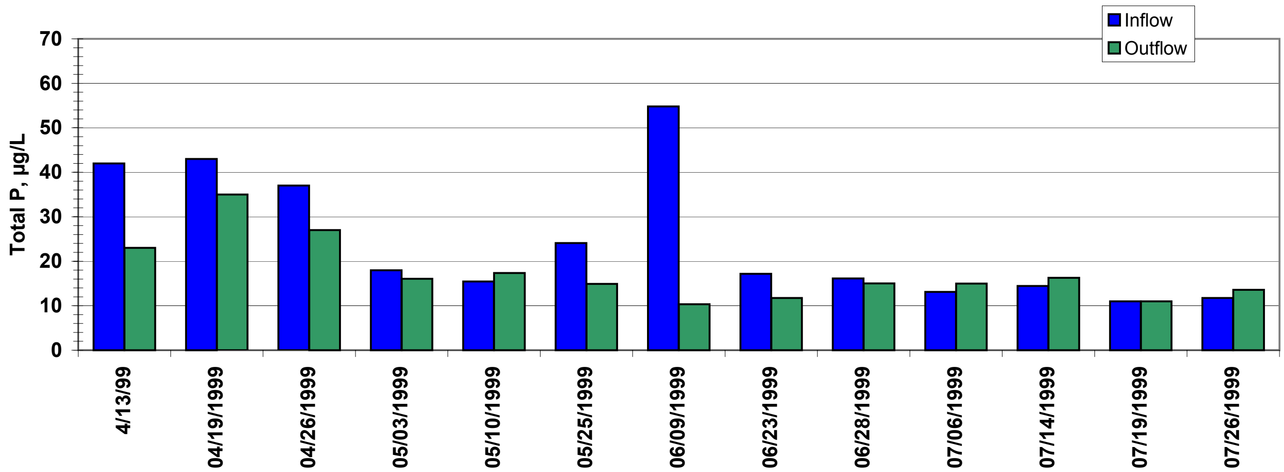
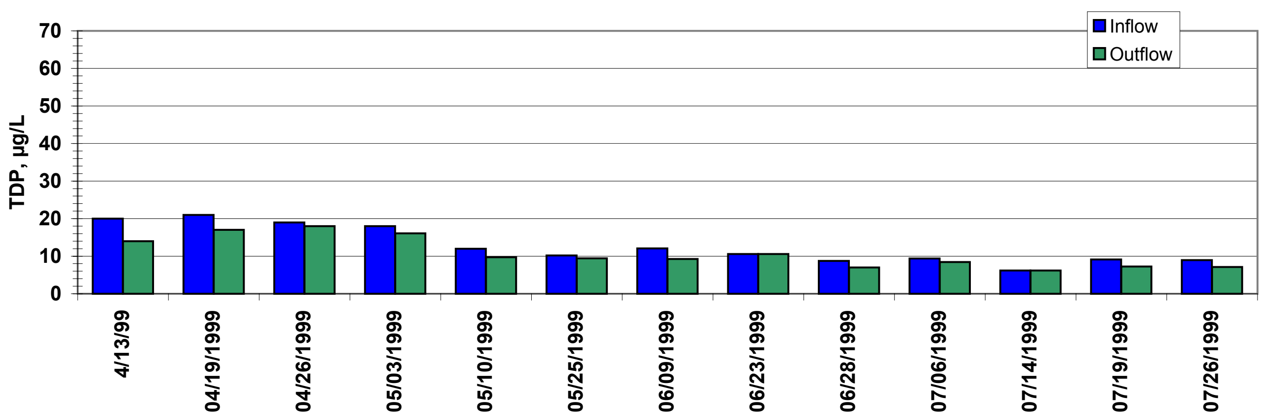


Exhibit 4-23
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 8, April - July 1999

TOTAL PHOSPHORUS



TOTAL DISSOLVED PHOSPHORUS



TOTAL PARTICULATE PHOSPHORUS

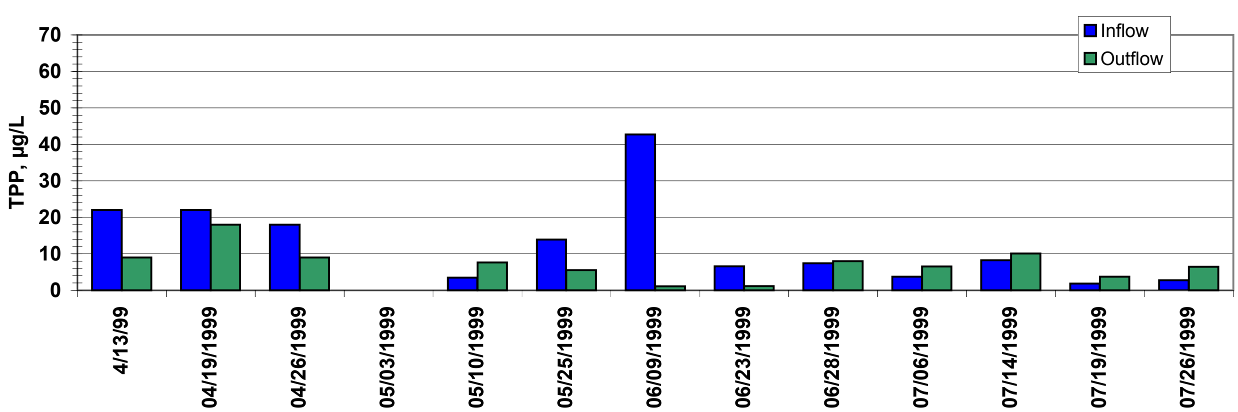


Exhibit 4-24
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 9, April - July 1999

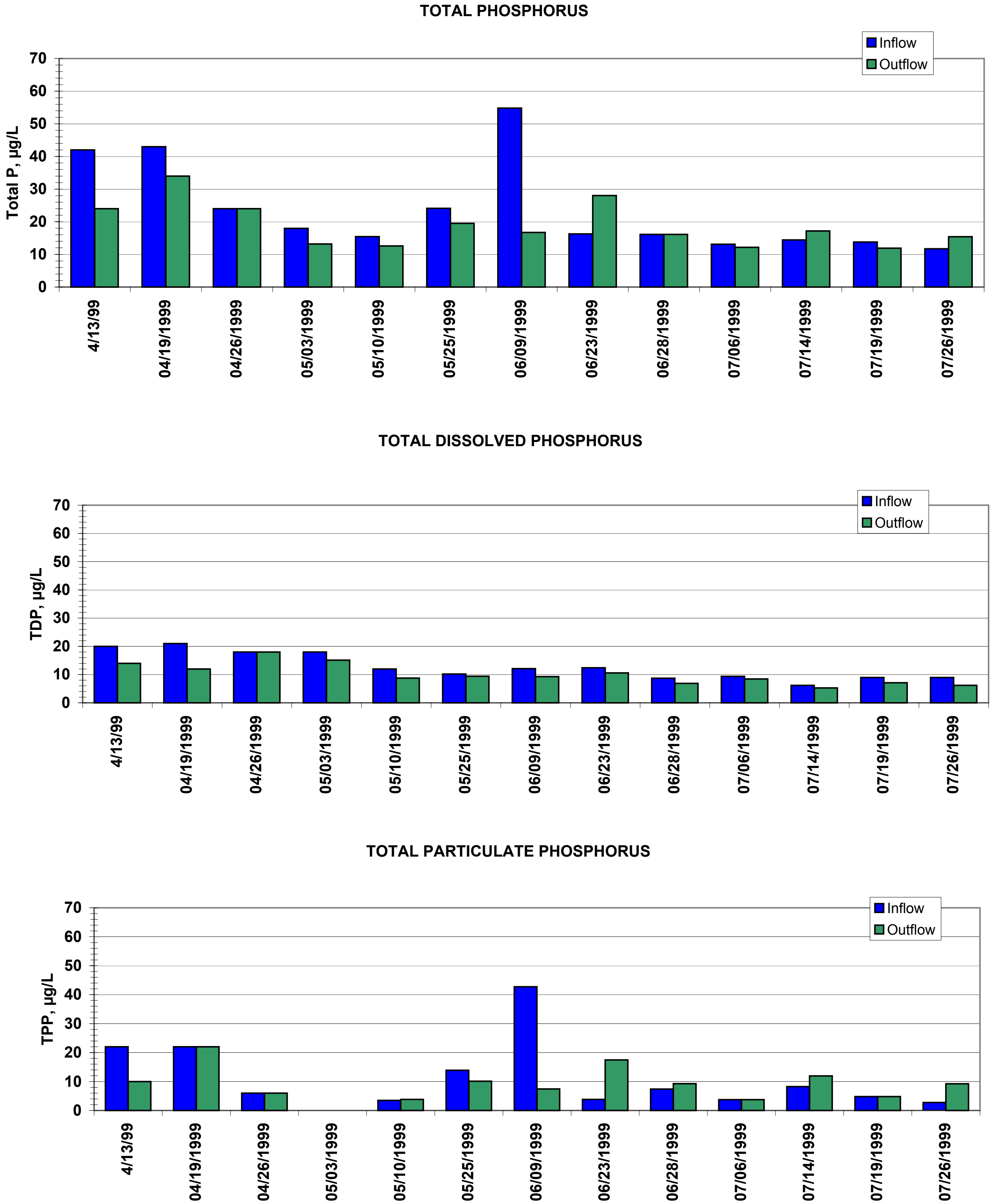
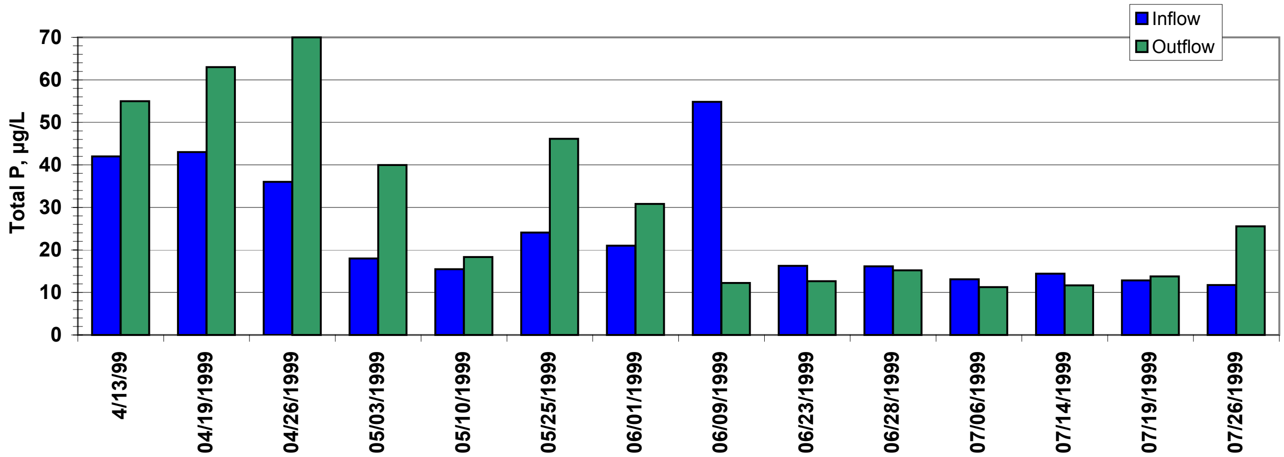
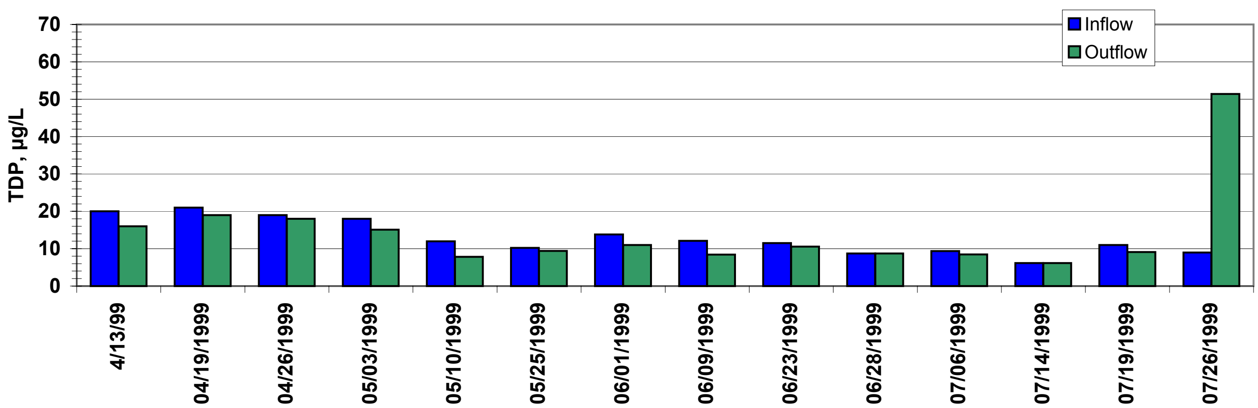


Exhibit 4-25
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 10, April - July 1999

TOTAL PHOSPHORUS



TOTAL DISSOLVED PHOSPHORUS



TOTAL PARTICULATE PHOSPHORUS

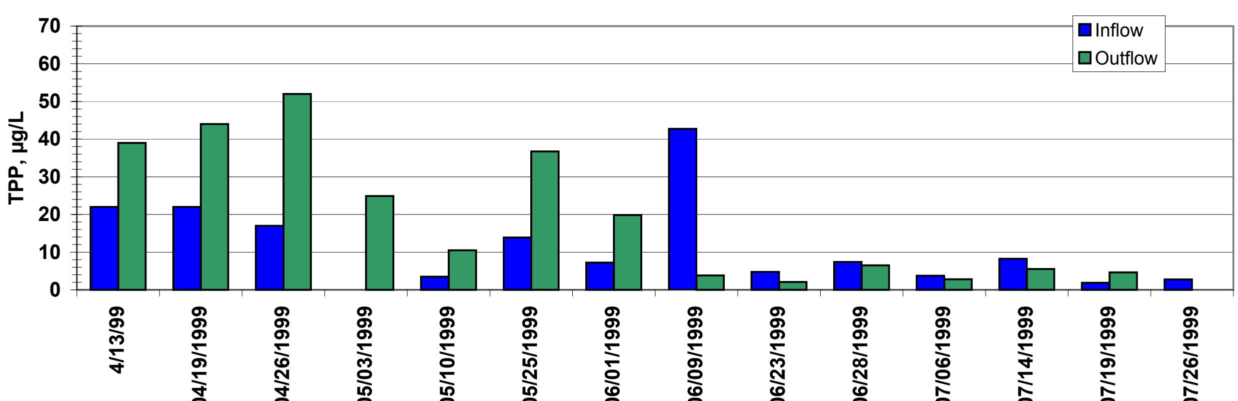
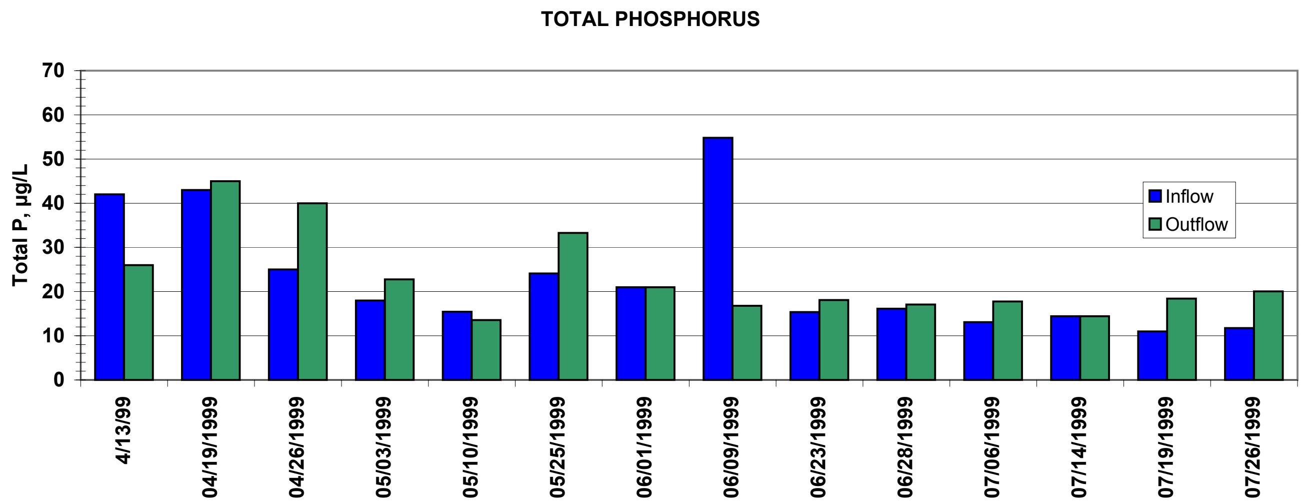
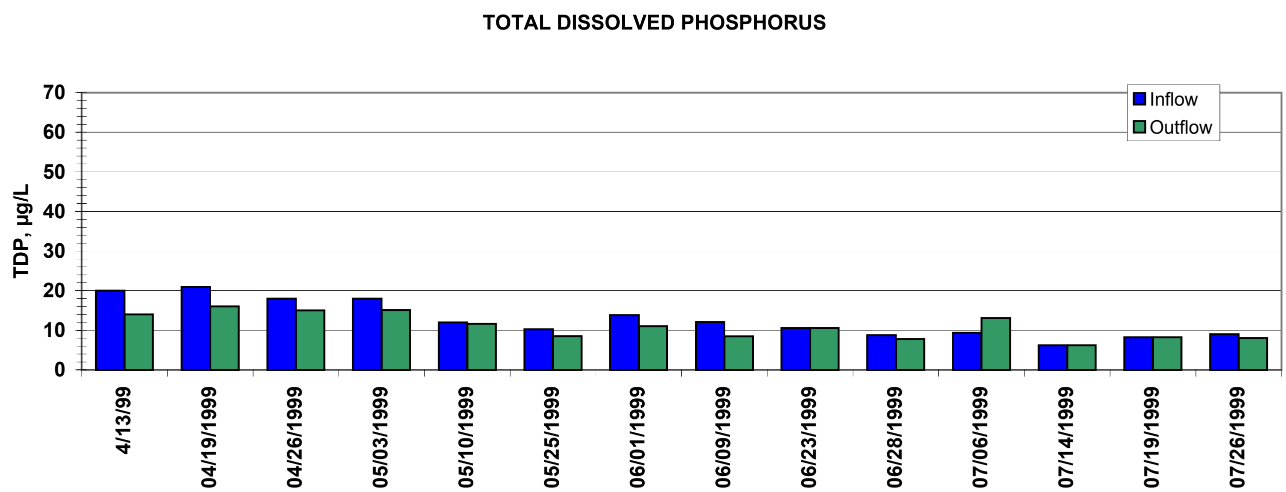


Exhibit 4-26
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 11, April - July 1999





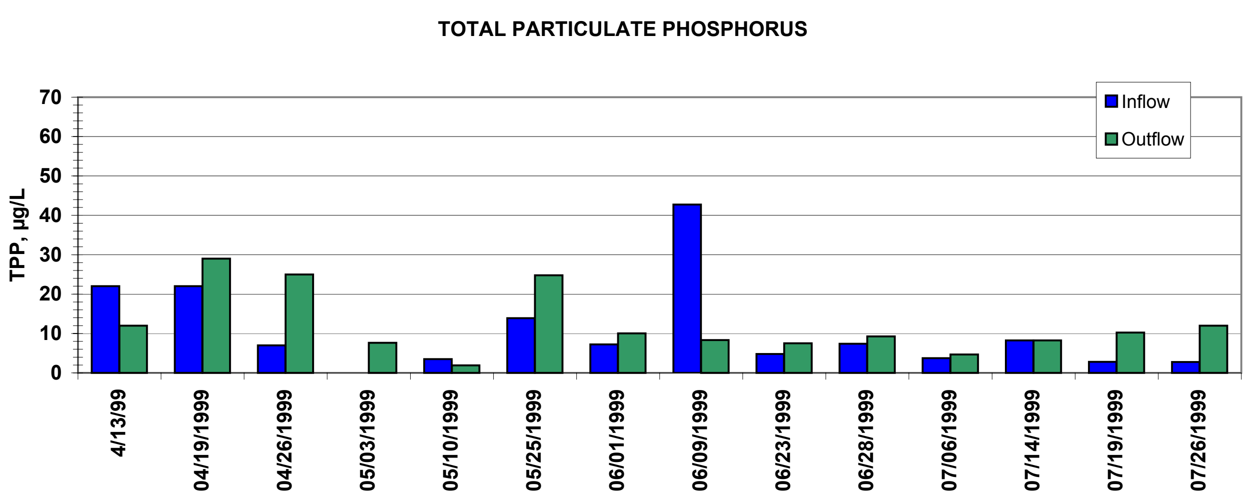


Exhibit 4-27
Inflow and Outflow Weekly Average Values for Total Phosphorus, Total Dissolved Phosphorus, and Total Particulate Phosphorus for Porta-PSTA Treatment No. 12, April - July 1999

Calcium: Inflow calcium concentrations to the mesocoms increased during the study period, with monthly averages ranging from 38.10 mg/L in April 1999 to 54.00 mg/L in July 1999 (All Treatments). Monthly average outflow calcium concentrations from the outflows ranged from 27.50 mg/L for Treatments 4 and 7 (May and June 1999) to 58.00 mg/L for Treatment 12 (July 1999).

Alkalinity: Monthly average inflow concentrations for alkalinity ranged from 160.0 mg/L in May 1999 (Treatment 7) to 220.0 mg/L in June 1999 for all treatments. The majority of outflow alkalinity concentrations were lower than corresponding inflow measurements, with averages ranging from 112.2 mg/L in May 1999 (Treatment 4) to 230.0 mg/L in April 1999 (Treatment 9).

Total Suspended Solids: TSS inflow concentrations ranged from BDL (4.0 mg/L) (All treatments) to 14.0 mg/L at Treatment 10 in May 1999. The highest outflow TSS concentrations were recorded in Treatment 10 with a monthly average of 32.0 mg/L in May 1999. All other TSS outflow concentrations ranged from BDL to 15 mg/L in June 1999 at Treatment 4.

Total Organic Carbon: Monthly average TOC inflow concentrations ranged from 18.40 mg/L in June 1999 to 32.00 mg/L in July 1999 at all 12 treatments. Monthly average outflow TOC concentrations ranged from 18.60 mg/L in June 1999 (Treatment 12) to 37.53 mg/L in April 1999 (Treatment 6).

4.6 Mass Balances

As a preliminary assessment of Porta-PSTA performance, inflow and outflow mass balances were estimated for each experimental mesocosm using the inflow and outflow concentration and HLR data presented in Section 4.2. Mean treatment inflow and outflow loads were used to calculate mean treatment removal rates for TP, TPP, TDP, and TN. First-order TP rate constants were calculated from the monthly data for three values of C*: 0.001 mg/L, 0.005 mg/L, and 0.010 mg/L. Contributions of rainfall to phosphorus and nitrogen loads to the Porta-PSTAs were not included in these mass loading estimates. Preliminary estimates indicate that rainfall load may make up between 1 to 10 percent of the total load. Final mass balance analyses for this project will include estimates of rainfall loads of TP and TN derived from available data.

To facilitate assessment of project treatment effects on system phosphorus removal performance, Exhibit 4-28 provides quarterly descriptive statistics for inflow and outflow hydraulic loading and phosphorus parameters. Exhibit 4-29 provides monthly treatment means for inflow and outflow TP parameters to provide a method of summarizing seasonal changes in system performance.

Exhibit 4-30 illustrates the relationship between TP mass loading and mass removal by treatment, and Exhibit 4-31 shows the relationship between TP mass loading and outflow TP concentration for the fourth quarter only. The results for the Test Cells are shown on the same graphs for comparison.

Exhibit 4-28
Porta-PSTA Mass Balance Phosphorus Data Summary

Treatment	Study Period	Summary Statistic	Inflow (m^3/d)	Outflow (m^3/d)	Avg_flow (m^3/d)	q_in (cm/d)	q_out (cm/d)	q_avg (cm/d)	TP (mg/L) Inflow	TP (mg/L) Outflow	TP ($g/m^2/y$) Inflow	TP ($g/m^2/y$) Outflow	TP ($g/m^2/y$) Removed	TP ($g/m^2/y$) %Removal	TPP (mg/L) Inflow	TPP (mg/L) Outflow	TPP ($g/m^2/y$) Inflow	TPP ($g/m^2/y$) Outflow	TPP ($g/m^2/y$) Removed	TPP ($g/m^2/y$) %Removal
1	Qtr-3	Mean	0.28	0.31	0.28	4.58	5.25	4.75	0.038	0.038	0.63	0.67	-0.04	-6%	0.018	0.023	0.30	0.39	-0.10	-33%
		Max	0.35	0.54	0.39	5.78	9.04	6.47	0.043	0.097	0.73	1.57			0.022	0.083	0.38	1.34		
		Min	0.22	0.00	0.14	3.74	0.00	2.28	0.028	0.021	0.50	0.00			0.008	0.005	0.17	0.00		
		Stdev	0.04	0.20	0.08	0.68	3.26	1.40	0.007	0.027	0.08	0.47			0.006	0.027	0.09	0.44		
		N	7	5	7	7	5	7	7	7	7	7			7	7	7	7		
1	Qtr-4	Mean	0.30	0.24	0.27	5.04	3.97	4.42	0.019	0.016	0.35	0.24	0.10	29%	0.008	0.007	0.16	0.11	0.05	30%
		Max	0.46	0.44	0.40	7.68	7.40	6.60	0.055	0.030	1.05	0.64			0.043	0.022	0.82	0.47		
		Min	0.17	0.00	0.00	2.90	0.00	0.00	0.011	0.009	0.00	0.00			-0.009	-0.003	-0.07	-0.06		
		Stdev	0.05	0.11	0.08	0.83	1.80	1.33	0.012	0.004	0.24	0.13			0.012	0.005	0.23	0.10		
		N	30	31	31	30	31	31	31	30	31	30			31	30	31	30		
2	Qtr-3	Mean	0.26	0.32	0.28	4.41	5.31	4.67	0.045	0.041	0.72	0.71	0.00	1%	0.025	0.026	0.40	0.45	-0.05	-13%
		Max	0.34	0.39	0.35	5.64	6.56	5.77	0.071	0.060	1.04	1.05			0.052	0.048	0.76	0.76		
		Min	0.13	0.21	0.13	2.16	3.52	2.16	0.035	0.025	0.34	0.26			0.017	0.005	0.17	0.12		
		Stdev	0.07	0.07	0.07	1.17	1.13	1.21	0.011	0.012	0.21	0.24			0.011	0.014	0.17	0.24		
		N	8	5	8	8	5	8	8	8	8	8			8	8	8	8		
2	Qtr-4	Mean	0.31	0.27	0.29	5.14	4.51	4.83	0.022	0.018	0.41	0.30	0.12	28%	0.011	0.009	0.22	0.14	0.08	35%
		Max	0.39	0.52	0.40	6.50	8.61	6.63	0.073	0.045	1.67	1.05			0.063	0.037	1.44	0.40		
		Min	0.22	0.05	0.16	3.66	0.81	2.62	0.012	0.009	0.17	0.05			0.000	-0.003	0.00	-0.05		
		Stdev	0.05	0.12	0.07	0.77	2.02	1.15	0.016	0.009	0.35	0.21			0.016	0.008	0.34	0.12		
		N	29	29	29	29	29	29	29	29	29	29			29	29	29	29		
3	Qtr-3	Mean	0.25	0.35	0.27	4.11	5.83	4.54	0.038	0.029	0.56	0.55	0.02	3%	0.018	0.014	0.26	0.27	-0.01	-3%
		Max	0.32	0.53	0.40	5.35	8.88	6.74	0.043	0.042	0.82	1.36			0.022	0.028	0.43	0.91		
		Min	0.16	0.24	0.16	2.69	4.08	2.69	0.024	0.015	0.41	0.26			0.006	0.002	0.10	0.04		
		Stdev	0.05	0.10	0.07	0.82	1.66	1.20	0.007	0.008	0.14	0.33			0.007	0.009	0.11	0.26		
		N	9	6	9	9	6	9	9	9	9	9			9	9	9	9		
3	Qtr-4	Mean	0.30	0.28	0.29	4.94	4.59	4.76	0.020	0.016	0.36	0.27	0.09	24%	0.008	0.007	0.15	0.13	0.02	15%
		Max	0.36	0.58	0.45	6.07	9.66	7.46	0.055	0.025	1.21	0.88			0.043	0.016	0.95	0.55		
		Min	0.22	0.00	0.11	3.64	0.00	1.82	0.012	0.009	0.16	0.00			-0.002	0.000	-0.04	0.00		
		Stdev	0.04	0.14	0.08	0.69	2.37	1.33	0.012	0.004	0.23	0.19			0.011	0.004	0.22	0.12		
		N	35	33	35	35	33	35	35	31	35	31			35	31	35	31		
4	Qtr-3	Mean	0.28	0.36	0.30	4.59	5.97	4.96	0.039	0.038	0.65	0.70	-0.05	-8%	0.019	0.025	0.32	0.45	-0.13	-40%
		Max	0.35	0.40	0.36	5.86	6.64	5.97	0.043	0.052	0.85	0.85			0.022	0.038	0.44	0.62		
		Min	0.22	0.27	0.22	3.66	4.56	3.68	0.028	0.022	0.37	0.51			0.005	0.009	0.07	0.21		
		Stdev	0.05	0.04	0.05	0.88	0.73	0.79	0.005	0.011	0.13	0.10			0.006	0.011	0.10	0.12		
		N	9	6	9	9	6	9	9	9	9	9			9	9	9	9		
4	Qtr-4	Mean	0.31	0.31	0.31	5.12	5.17	5.13	0.019	0.018	0.36	0.35	0.01	3%	0.008	0.010	0.15	0.19	-0.04	-26%
		Max	0.40	0.94	0.61	6.72	15.60	10.20	0.055	0.033	1.10	1.24			0.043	0.025	0.86	0.76		
		Min	0.23	0.11	0.20	3.82	1.76	3.29	0.011	0.011	0.20	0.10			-0.002	-0.001	-0.05	-0.01		
		Stdev	0.04	0.15	0.08	0.63	2.55	1.33	0.012	0.006	0.21	0.25			0.012	0.006	0.21	0.18		
		N	34	33	34	34	33	34	34	31	34	31			34	31	34	31		
5	Qtr-3	Mean	0.60	0.68	0.63	9.92	11.41	10.52	0.039	0.033	1.40	1.32	0.09	6%	0.019	0.017	0.68	0.68	0.00	0%
		Max	0.74	0.72	0.71	12.34	11.92	11.85	0.043	0.037	1.89	1.46			0.022	0.023	0.99	0.99		
		Min	0.40	0.66	0.53	6.67	11.04	8.90	0.027	0.027	1.02	1.09			0.008	0.009	0.31	0.36		
		Stdev	0.10	0.02	0.06	1.71	0.32	1.00	0.006	0.003	0.35	0.11			0.005	0.004	0.24	0.17		
		N	9	6	9	9	6	9	9	9	9	9			9	9	9	9		
5	Qtr-4	Mean	0.57	0.56	0.57	9.46	9.40	9.43	0.020	0.018	0.67	0.61	0.07	10%	0.009	0.009	0.30	0.32	-0.02	-5%
		Max	0.72	0.91	0.75	12.04	15.12	12.57	0.055	0.053	1.97	2.18			0.043	0.046	1.53	1.87		
		Min	0.40	0.00	0.24	6.62	0.00	4.02	0.012	0.010	0.37	0.00			0.000	0.001	0.00	0.00		
		Stdev	0.09	0.18	0.11	1.48	3.05	1.85	0.012	0.010	0.42	0.42			0.012	0.010	0.40	0.39		
		N	33	33	33	33	33	33	33	29	33	29			33	29	33	29		
6	Qtr-3	Mean	0.18	0.24	0.20	3.07	3.95	3.31	0.038	0.037	0.43	0.47	-0.04	-10%	0.018	0.025	0.20	0.31	-0.11	-52%
		Max	0.28	0.35	0.31	4.64	5.76	5.20	0.043	0.054	0.71	0.80			0.022	0.043	0.37	0.50		
		Min	0.12	0.18	0.15	2.04	3.00	2.43	0.028	0.024	0.22	0.26			0.009	0.011	0.07	0.12		
		Stdev	0.05	0.06	0.05	0.76	1.07	0.85	0.007	0.009	0.14	0.16			0.006	0.010	0.10	0.13		
		N	9	6	9	9	6	9	9	9	9	9			9	9	9	9		
6	Qtr-4	Mean	0.37	0.35	0.36	6.23	5.81	6.05	0.020	0.020	0.44	0.35	0.09	20%	0.008	0.011	0.21	0.20	0.02	8%
		Max	0.59	0.58	0.59	9.86	9.74	9.75	0.055	0.059	1.51	1.10			0.043	0.051	1.18	0.86		
		Min	0.10	0.00	0.06	1.73	0.00	1.06	0.012	0.012	0.10	0.00			-0.001	0.003	0.00	0.00		
		Stdev	0.16	0.19	0.17	2.72	3.21	2.81	0.012	0.011	0.35	0.23			0.012	0.011	0.31	0.18		
		N	33	30	33	33	30	33	33	30	33	30			33	30	33	30		

Exhibit 4-28
Porta-PSTA Mass Balance Phosphorus Data Summary

	Study	Summary	Inflow	Outflow	Avg_flow	q_in	q_out	q_avg	TP (mg/L)		TP (g/m²/y)				TPP (mg/L)		TPP (g/m²/y)			
Treatment	Period	Statistic	(m^3/d)	(m^3/d)	(m^3/d)	(cm/d)	(cm/d)	(cm/d)	Inflow	Outflow	Inflow	Outflow	Removed	%Removal	Inflow	Outflow	Inflow	Outflow	Removed	%Removal
7	Qtr-3	Mean	0.31	0.26	0.30	5.19	4.30	4.92	0.040	0.062	0.76	1.14	-0.38	-51%	0.020	0.044	0.38	0.84	-0.46	-122%
		Max	0.32	0.31	0.32	5.37	5.12	5.37	0.043	0.130	0.84	2.55			0.022	0.109	0.43	2.13		
		Min	0.29	0.21	0.27	4.82	3.48	4.43	0.035	0.026	0.69	0.38			0.016	0.012	0.31	0.15		
		Stdev	0.02	0.07	0.03	0.31	1.16	0.47	0.004	0.059	0.08	1.22			0.003	0.056	0.06	1.12		
		N	3	2	3	3	2	3	3	3	3	3			3	3	3	3		
7	Qtr-4	Mean	0.32	0.37	0.34	5.31	6.12	5.71	0.020	0.017	0.37	0.41	-0.04	-10%	0.009	0.008	0.17	0.23	-0.06	-33%
		Max	0.40	0.75	0.53	6.59	12.52	8.79	0.055	0.037	1.01	1.29			0.043	0.028	0.79	1.00		
		Min	0.25	0.08	0.20	4.15	1.32	3.34	0.012	0.012	0.23	0.18			0.000	-0.003	0.00	-0.04		
		Stdev	0.04	0.19	0.09	0.68	3.13	1.53	0.012	0.008	0.22	0.35			0.012	0.008	0.22	0.30		
		N	11	11	11	11	11	11	11	9	11	9			11	9	11	9		
8	Qtr-3	Mean	0.35	1.58	0.76	5.89	26.40	12.65	0.037	0.047	0.78	2.04	-1.26	-160%	0.017	0.031	0.36	1.02	-0.66	-186%
		Max	0.39	2.88	1.61	6.44	48.00	26.90	0.043	0.088	0.89	3.85			0.022	0.070	0.47	1.40		
		Min	0.33	0.29	0.33	5.43	4.80	5.43	0.026	0.022	0.61	0.53			0.007	0.008	0.16	0.26		
		Stdev	0.03	1.83	0.74	0.51	30.55	12.34	0.010	0.036	0.15	1.68			0.009	0.034	0.17	0.65		
		N	3	2	3	3	2	3	3	3	3	3			3	3	3	3		
8	Qtr-4	Mean	0.35	0.23	0.29	5.84	3.85	4.84	0.020	0.019	0.41	0.28	0.13	31%	0.009	0.010	0.19	0.16	0.03	18%
		Max	0.73	0.45	0.59	12.18	7.50	9.84	0.055	0.031	1.12	0.55			0.043	0.020	0.87	0.38		
		Min	0.23	0.04	0.17	3.90	0.60	2.79	0.012	0.013	0.22	0.04			0.000	0.003	0.00	0.01		
		Stdev	0.13	0.13	0.12	2.21	2.24	1.95	0.012	0.006	0.27	0.16			0.012	0.006	0.24	0.12		
		N	11	11	11	11	11	11	11	10	11	10			11	10	11	10		
9	Qtr-3	Mean	0.37	0.35	0.38	6.25	5.76	6.31	0.041	0.028	0.93	0.67	0.25	27%	0.021	0.012	0.47	0.29	0.18	38%
		Max	0.46	0.35	0.46	7.62	5.76	7.62	0.043	0.035	1.20	0.97			0.022	0.018	0.61	0.50		
		Min	0.30	0.35	0.32	4.97	5.76	5.36	0.037	0.023	0.76	0.48			0.018	0.009	0.40	0.19		
		Stdev	0.08	0.00	0.07	1.33	0.00	1.17	0.003	0.006	0.23	0.26			0.002	0.005	0.12	0.18		
		N	3	2	3	3	2	3	3	3	3	3			3	3	3	3		
9	Qtr-4	Mean	0.30	0.22	0.26	5.08	3.71	4.40	0.019	0.014	0.35	0.18	0.17	48%	0.009	0.005	0.16	0.06	0.09	59%
		Max	0.36	0.39	0.37	5.94	6.44	6.19	0.055	0.017	0.91	0.29			0.043	0.010	0.71	0.16		
		Min	0.26	0.00	0.17	4.25	0.00	2.88	0.011	0.010	0.18	0.00			0.000	0.000	0.00	0.00		
		Stdev	0.04	0.11	0.06	0.59	1.77	1.01	0.012	0.002	0.20	0.09			0.012	0.003	0.19	0.06		
		N	11	11	11	11	11	11	11	10	11	10			11	10	11	10		
10	Qtr-3	Mean	0.44	0.28	0.44	7.28	4.68	7.40	0.036	0.027	1.03	0.82	0.22	21%	0.017	0.013	0.50	0.44	0.05	11%
		Max	0.79	0.29	0.79	13.18	4.80	13.18	0.043	0.034	2.07	1.64			0.022	0.022	1.06	1.06		
		Min	0.25	0.27	0.26	4.19	4.56	4.38	0.024	0.024	0.39	0.40			0.006	0.006	0.10	0.11		
		Stdev	0.31	0.01	0.30	5.11	0.17	5.01	0.011	0.006	0.90	0.71			0.009	0.008	0.50	0.53		
		N	3	2	3	3	2	3	3	3	3	3			3	3	3	3		
10	Qtr-4	Mean	0.28	0.18	0.23	4.69	2.98	3.85	0.020	0.016	0.33	0.21	0.12	35%	0.009	0.008	0.15	0.11	0.04	27%
		Max	0.34	0.36	0.35	5.60	6.08	5.82	0.055	0.028	0.91	0.62			0.043	0.017	0.71	0.39		
		Min	0.20	0.00	0.13	3.36	0.00	2.20	0.012	0.012	0.19	0.06			0.000	-0.002	0.00	-0.01		
		Stdev	0.05	0.11	0.07	0.78	1.77	1.10	0.012	0.005	0.20	0.16			0.012	0.005	0.19	0.11		
		N	11	10	11	11	10	11	11	10	11	10			11	10	11	10		
11	Qtr-3	Mean	0.88	0.89	0.88	4.87	4.92	4.88	0.040	0.063	0.72	1.14	-0.42	-59%	0.020	0.045	0.36	0.82	-0.46	-127%
		Max	0.90	1.07	0.98	5.01	5.92	5.47	0.043	0.070	0.75	1.51			0.022	0.052	0.39	1.12		
		Min	0.86	0.71	0.78	4.79	3.92	4.35	0.036	0.055	0.66	0.79			0.017	0.039	0.31	0.56		
		Stdev	0.02	0.25	0.10	0.12	1.41	0.56	0.004	0.008	0.05	0.36			0.003	0.007	0.04	0.29		
		N	3	2	3	3	2	3	3	3	3	3			3	3	3	3		
11	Qtr-4	Mean	1.00	0.97	0.99	5.53	5.38	5.48	0.020	0.022	0.40	0.47	-0.07	-16%	0.008	0.008	0.17	0.18	-0.01	-3%
		Max	1.07	1.40	1.20	5.95	7.80	6.67	0.055	0.046	1.14	1.31			0.043	0.037	0.89	1.05		
		Min	0.83	0.09	0.55	4.64	0.52	3.05	0.012	0.011	0.22	0.03			0.000	-0.026	0.00	-0.64		
		Stdev	0.07	0.36	0.17	0.41	2.02	0.94	0.012	0.012	0.25	0.37			0.011	0.016	0.24	0.41		
		N	12	11	12	12	11	12	12	11	12	11			12	11	12	11		
12	Qtr-3	Mean	0.97	0.92	0.97	5.40	5.12	5.39	0.037	0.037	0.71	0.74	-0.03	-4%	0.017	0.022	0.33	0.44	-0.12	-36%
		Max	1.07	0.95	1.07	5.93	5.28	5.93	0.043	0.045	0.93	0.97			0.022	0.029	0.48	0.63		
		Min	0.78	0.89	0.84	4.35	4.96	4.65	0.025	0.026	0.54	0.47			0.007	0.012	0.15	0.22		
		Stdev	0.16	0.04	0.12	0.91	0.23	0.66	0.010	0.010	0.20	0.25			0.009	0.009	0.16	0.21		
		N	3	2	3	3	2	3	3	3	3	3			3	3	3	3		
12	Qtr-4	Mean	1.01	1.09	1.05	5.60	6.06	5.81	0.019	0.019	0.39	0.42	-0.04	-9%	0.009	0.010	0.17	0.21	-0.04	-26%
		Max	1.13	1.40	1.23	6.29	7.80	6.86	0.055	0.033	1.05	0.95			0.043	0.025	0.82	0.71		
		Min	0.80	0.85	0.89	4.45	4.72	4.97	0.011	0.014	0.24	0.29			0.000	0.002	0.00	0.05		
		Stdev	0.11	0.21	0.11	0.63	1.14	0.63	0.012	0.005	0.22	0.18			0.011	0.006	0.21	0.18		
		N	12	11	12	12	11	12	12	11	12	11			12	11	12	11		

Exhibit 4-28
Porta-PSTA Mass Balance Phosphorus Data Summary

Treatment	Study Period	Summary Statistic	TDP (mg/L) Inflow	TDP (mg/L) Outflow	TDP ($g/m^2/y$) Inflow	TDP ($g/m^2/y$) Outflow	TDP ($g/m^2/y$) Removed	TDP ($g/m^2/y$) %Removal	SRP (mg/L) Inflow	SRP (mg/L) Outflow	SRP ($g/m^2/y$) Inflow	SRP ($g/m^2/y$) Outflow	SRP ($g/m^2/y$) Removed	SRP ($g/m^2/y$) %Removal	DOP (mg/L) Inflow	DOP (mg/L) Outflow	DOP ($g/m^2/y$) Inflow	DOP ($g/m^2/y$) Outflow	DOP ($g/m^2/y$) Removed	DOP ($g/m^2/y$) %Removal
1	Qtr-3	Mean	0.020	0.015	0.34	0.28	0.06	18%	0.005	0.004	0.091	0.088	0.00	3%	0.015	0.011	0.25	0.19	0.06	23%
		Max	0.021	0.019	0.44	0.56			0.006	0.011	0.106	0.363			0.016	0.015	0.34	0.32		
		Min	0.018	0.012	0.29	0.00			0.005	0.001	0.068	0.000			0.013	0.006	0.20	0.00		
		Stdev	0.001	0.002	0.05	0.18			0.001	0.003	0.014	0.125			0.001	0.003	0.04	0.10		
		N	7	7	7	7			7	7	7	7			7	7	7	7		
1	Qtr-4	Mean	0.011	0.009	0.19	0.13	0.05	29%	0.003	0.002	0.058	0.034	0.02	41%	0.008	0.007	0.13	0.10	0.03	24%
		Max	0.025	0.020	0.30	0.24			0.005	0.004	0.088	0.063			0.021	0.018	0.25	0.20		
		Min	0.006	0.006	0.00	0.00			0.002	0.001	0.000	0.000			0.004	0.003	0.00	0.00		
		Stdev	0.004	0.003	0.06	0.06			0.001	0.001	0.019	0.017			0.004	0.003	0.05	0.05		
		N	31	30	31	30			31	30	31	30			31	30	31	30		
2	Qtr-3	Mean	0.020	0.014	0.32	0.26	0.06	18%	0.005	0.005	0.079	0.076	0.00	5%	0.015	0.009	0.24	0.19	0.05	22%
		Max	0.021	0.020	0.43	0.48			0.006	0.020	0.109	0.158			0.016	0.015	0.33	0.36		
		Min	0.018	0.011	0.17	0.09			0.003	0.001	0.039	0.019			0.014	-0.009	0.13	-0.07		
		Stdev	0.001	0.003	0.08	0.12			0.001	0.006	0.024	0.049			0.001	0.008	0.07	0.13		
		N	8	8	8	8			8	8	8	8			8	8	8	8		
2	Qtr-4	Mean	0.011	0.009	0.20	0.16	0.04	20%	0.003	0.003	0.059	0.054	0.00	7%	0.008	0.006	0.14	0.10	0.03	25%
		Max	0.018	0.032	0.29	0.74			0.005	0.019	0.109	0.448			0.014	0.013	0.24	0.29		
		Min	0.006	0.006	0.10	0.02			0.002	0.001	0.030	0.008			0.004	0.003	0.06	0.01		
		Stdev	0.003	0.005	0.05	0.13			0.001	0.003	0.017	0.080			0.003	0.002	0.05	0.06		
		N	29	29	29	29			29	29	29	29			29	29	29	29		
3	Qtr-3	Mean	0.020	0.015	0.30	0.28	0.02	8%	0.005	0.003	0.079	0.056	0.02	29%	0.015	0.013	0.22	0.22	0.00	0%
		Max	0.021	0.018	0.39	0.45			0.006	0.005	0.117	0.130			0.016	0.016	0.27	0.34		
		Min	0.018	0.013	0.21	0.16			0.004	0.001	0.049	0.012			0.013	0.009	0.16	0.13		
		Stdev	0.001	0.002	0.05	0.10			0.001	0.001	0.021	0.038			0.001	0.003	0.04	0.08		
		N	9	9	9	9			9	9	9	9			9	9	9	9		
3	Qtr-4	Mean	0.011	0.009	0.20	0.14	0.06	30%	0.003	0.002	0.056	0.036	0.02	37%	0.008	0.006	0.15	0.11	0.04	28%
		Max	0.019	0.015	0.42	0.33			0.005	0.004	0.098	0.107			0.015	0.012	0.33	0.29		
		Min	0.006	0.006	0.09	0.00			0.000	0.000	0.003	0.000			0.004	0.003	0.06	0.00		
		Stdev	0.003	0.002	0.06	0.08			0.001	0.001	0.023	0.024			0.003	0.002	0.06	0.07		
		N	35	31	35	31			35	30	35	30			35	30	35	30		
4	Qtr-3	Mean	0.020	0.013	0.33	0.26	0.08	23%	0.005	0.003	0.082	0.056	0.03	31%	0.015	0.010	0.25	0.20	0.05	21%
		Max	0.023	0.015	0.40	0.34			0.006	0.006	0.121	0.140			0.017	0.013	0.32	0.29		
		Min	0.017	0.012	0.28	0.17			0.003	0.001	0.063	0.015			0.014	0.007	0.21	0.16		
		Stdev	0.002	0.001	0.04	0.06			0.001	0.002	0.019	0.043			0.001	0.002	0.04	0.04		
		N	9	9	9	9			9	9	9	9			9	9	9	9		
4	Qtr-4	Mean	0.011	0.009	0.21	0.16	0.05	24%	0.003	0.003	0.060	0.049	0.01	20%	0.008	0.006	0.15	0.11	0.04	26%
		Max	0.018	0.016	0.32	0.48			0.005	0.005	0.109	0.194			0.014	0.013	0.25	0.29		
		Min	0.006	0.006	0.12	0.04			0.000	0.001	0.003	0.010			0.004	0.002	0.07	0.02		
		Stdev	0.003	0.002	0.05	0.09			0.001	0.001	0.022	0.036			0.003	0.002	0.05	0.06		
		N	34	31	34	31			34	31	34	31			34	31	34	31		
5	Qtr-3	Mean	0.020	0.016	0.72	0.63	0.09	12%	0.005	0.003	0.178	0.119	0.06	33%	0.015	0.013	0.54	0.51	0.03	6%
		Max	0.021	0.018	0.90	0.76			0.006	0.007	0.270	0.305			0.016	0.016	0.69	0.67		
		Min	0.017	0.011	0.49	0.47			0.003	0.001	0.090	0.038			0.014	0.008	0.34	0.35		
		Stdev	0.001	0.002	0.15	0.08			0.001	0.002	0.053	0.088			0.001	0.003	0.11	0.11		
		N	9	9	9	9			9	9	9	9			9	9	9	9		
5	Qtr-4	Mean	0.011	0.009	0.37	0.29	0.08	22%	0.003	0.002	0.109	0.072	0.04	34%	0.008	0.007	0.26	0.22	0.04	17%
		Max	0.018	0.017	0.53	0.68			0.005	0.004	0.184	0.160			0.014	0.015	0.42	0.54		
		Min	0.006	0.006	0.18	0.00			0.002	0.001	0.065	0.000			0.004	0.004	0.11	0.00		
		Stdev	0.003	0.003	0.09	0.14			0.001	0.001	0.035	0.032			0.003	0.003	0.08	0.12		
		N	33	29	33	29			33	29	33	29			33	29	33	29		
6	Qtr-3	Mean	0.020	0.012	0.23	0.16	0.06	28%	0.005	0.003	0.057	0.037	0.02	35%	0.015	0.010	0.17	0.13	0.04	25%
		Max	0.021	0.014	0.34	0.29			0.006	0.005	0.102	0.086			0.016	0.012	0.24	0.23		
		Min	0.019	0.011	0.15	0.10			0.003	0.002	0.030	0.018			0.014	0.008	0.12	0.08		
		Stdev	0.001	0.001	0.05	0.06			0.001	0.001	0.022	0.024			0.001	0.001	0.04	0.05		
		N	9	9	9	9			9	9	9	9			9	9	9	9		
6	Qtr-4	Mean	0.011	0.009	0.23	0.16	0.07	31%	0.003	0.003	0.071	0.050	0.02	29%	0.008	0.006	0.16	0.11	0.05	33%
		Max	0.018	0.014	0.37	0.27			0.004	0.004	0.150	0.114			0.014	0.011	0.31	0.19		
		Min	0.006	0.004	0.08	0.00			0.002	0.001	0.021	0.000			0.004	0.003	0.05	0.00		
		Stdev	0.003	0.003	0.09	0.08			0.001	0.001	0.038	0.032			0.003	0.002	0.06	0.06		
		N	33	30	33	30			33	30	33	30			33	30	33	30		

Exhibit 4-28
Porta-PSTA Mass Balance Phosphorus Data Summary

	Study	Summary	TDP (mg/L)		TDP (g/m²/y)				SRP (mg/L)		SRP (g/m²/y)				DOP (mg/L)		DOP (g/m²/y)			
Treatment	Period	Statistic	Inflow	Outflow	Inflow	Outflow	Removed	%Removal	Inflow	Outflow	Inflow	Outflow	Removed	%Removal	Inflow	Outflow	Inflow	Outflow	Removed	%Removal
7	Qtr-3	Mean	0.020	0.018	0.38	0.30	0.08	21%	0.005	0.005	0.094	0.083	0.01	12%	0.015	0.013	0.28	0.22	0.07	24%
		Max	0.021	0.021	0.41	0.41			0.006	0.006	0.106	0.118			0.016	0.015	0.31	0.29		
		Min	0.019	0.014	0.35	0.23			0.004	0.003	0.078	0.038			0.014	0.009	0.25	0.17		
		Stdev	0.001	0.004	0.03	0.10			0.001	0.002	0.014	0.041			0.001	0.003	0.03	0.07		
		N	3	3	3	3			3	3	3	3			3	3	3	3		
7	Qtr-4	Mean	0.011	0.009	0.20	0.18	0.02	9%	0.003	0.002	0.063	0.050	0.01	20%	0.007	0.006	0.14	0.13	0.01	5%
		Max	0.018	0.017	0.33	0.29			0.004	0.003	0.097	0.078			0.014	0.015	0.26	0.21		
		Min	0.006	0.006	0.15	0.09			0.002	0.001	0.034	0.016			0.004	0.002	0.09	0.05		
		Stdev	0.003	0.004	0.05	0.07			0.001	0.001	0.020	0.023			0.003	0.003	0.04	0.06		
		N	11	9	11	9			11	9	11	9			11	9	11	9		
8	Qtr-3	Mean	0.020	0.016	0.43	1.02	-0.60	-139%	0.005	0.003	0.107	0.310	-0.20	-191%	0.015	0.013	0.32	0.71	-0.39	-122%
		Max	0.021	0.018	0.45	2.45			0.006	0.005	0.127	0.876			0.016	0.017	0.35	1.58		
		Min	0.019	0.014	0.42	0.26			0.004	0.001	0.094	0.020			0.014	0.009	0.30	0.23		
		Stdev	0.001	0.002	0.02	1.24			0.001	0.002	0.018	0.490			0.001	0.004	0.03	0.75		
		N	3	3	3	3			3	3	3	3			3	3	3	3		
8	Qtr-4	Mean	0.011	0.009	0.22	0.13	0.09	43%	0.003	0.002	0.066	0.035	0.03	48%	0.007	0.006	0.15	0.09	0.06	41%
		Max	0.018	0.013	0.39	0.23			0.004	0.003	0.120	0.077			0.014	0.010	0.27	0.19		
		Min	0.006	0.006	0.12	0.03			0.002	0.001	0.030	0.006			0.004	0.003	0.07	0.02		
		Stdev	0.003	0.003	0.08	0.07			0.001	0.000	0.026	0.021			0.003	0.003	0.06	0.05		
		N	11	10	11	10			11	10	11	10			11	10	11	10		
9	Qtr-3	Mean	0.020	0.016	0.46	0.38	0.08	17%	0.006	0.004	0.128	0.089	0.04	31%	0.014	0.012	0.33	0.29	0.04	11%
		Max	0.021	0.018	0.58	0.47			0.006	0.007	0.139	0.147			0.016	0.015	0.45	0.42		
		Min	0.019	0.014	0.36	0.29			0.005	0.002	0.109	0.056			0.013	0.007	0.25	0.15		
		Stdev	0.001	0.002	0.11	0.09			0.001	0.003	0.016	0.051			0.002	0.005	0.10	0.14		
		N	3	3	3	3			3	3	3	3			3	3	3	3		
9	Qtr-4	Mean	0.011	0.009	0.19	0.12	0.07	38%	0.003	0.003	0.059	0.034	0.02	42%	0.007	0.006	0.14	0.09	0.05	36%
		Max	0.018	0.016	0.28	0.25			0.004	0.005	0.077	0.071			0.014	0.013	0.22	0.20		
		Min	0.006	0.006	0.13	0.00			0.002	0.001	0.031	0.000			0.004	0.004	0.08	0.00		
		Stdev	0.003	0.003	0.04	0.06			0.001	0.001	0.013	0.021			0.003	0.003	0.04	0.05		
		N	11	10	11	10			11	10	11	10			11	10	11	10		
10	Qtr-3	Mean	0.020	0.015	0.54	0.38	0.16	30%	0.005	0.005	0.138	0.100	0.04	27%	0.014	0.010	0.40	0.28	0.12	31%
		Max	0.021	0.018	1.01	0.58			0.006	0.007	0.240	0.117			0.016	0.013	0.77	0.48		
		Min	0.018	0.012	0.29	0.23			0.005	0.002	0.082	0.088			0.013	0.007	0.21	0.12		
		Stdev	0.002	0.003	0.41	0.18			0.001	0.003	0.089	0.015			0.002	0.003	0.32	0.19		
		N	3	3	3	3			3	3	3	3			3	3	3	3		
10	Qtr-4	Mean	0.011	0.009	0.18	0.10	0.08	42%	0.003	0.003	0.057	0.031	0.03	45%	0.007	0.006	0.12	0.07	0.05	41%
		Max	0.018	0.015	0.25	0.23			0.005	0.006	0.074	0.075			0.014	0.012	0.19	0.19		
		Min	0.006	0.005	0.12	0.05			0.002	0.001	0.022	0.011			0.004	0.003	0.07	0.03		
		Stdev	0.003	0.003	0.04	0.05			0.001	0.001	0.015	0.019			0.003	0.003	0.04	0.05		
		N	11	10	11	10			11	10	11	10			11	10	11	10		
11	Qtr-3	Mean	0.020	0.018	0.36	0.32	0.04	11%	0.006	0.003	0.101	0.057	0.04	43%	0.014	0.014	0.25	0.26	-0.01	-2%
		Max	0.021	0.019	0.37	0.39			0.006	0.005	0.110	0.072			0.016	0.017	0.28	0.32		
		Min	0.019	0.016	0.35	0.23			0.005	0.002	0.088	0.035			0.013	0.011	0.24	0.16		
		Stdev	0.001	0.002	0.01	0.08			0.001	0.002	0.012	0.019			0.002	0.003	0.02	0.09		
		N	3	3	3	3			3	3	3	3			3	3	3	3		
11	Qtr-4	Mean	0.011	0.013	0.23	0.29	-0.06	-26%	0.003	0.002	0.062	0.051	0.01	17%	0.008	0.011	0.17	0.24	-0.07	-42%
		Max	0.018	0.051	0.32	1.26			0.004	0.005	0.092	0.120			0.014	0.050	0.29	1.23		
		Min	0.006	0.006	0.10	0.01			0.000	0.000	0.004	0.004			0.004	0.001	0.06	0.01		
		Stdev	0.003	0.013	0.06	0.33			0.001	0.001	0.025	0.032			0.003	0.013	0.07	0.34		
		N	12	11	12	11			12	11	12	11			12	11	12	11		
12	Qtr-3	Mean	0.020	0.015	0.39	0.30	0.09	23%	0.005	0.003	0.104	0.065	0.04	37%	0.014	0.012	0.28	0.23	0.05	18%
		Max	0.021	0.016	0.45	0.35			0.006	0.004	0.108	0.072			0.016	0.013	0.35	0.28		
		Min	0.018	0.014	0.32	0.25			0.005	0.003	0.095	0.058			0.013	0.010	0.22	0.18		
		Stdev	0.002	0.001	0.07	0.05			0.001	0.001	0.007	0.007			0.002	0.002	0.06	0.05		
		N	3	3	3	3			3	3	3	3			3	3	3	3		
12	Qtr-4	Mean	0.011	0.010	0.22	0.21	0.01	4%	0.003	0.002	0.063	0.049	0.01	23%	0.008	0.007	0.15	0.16	0.00	-3%
		Max	0.018	0.015	0.34	0.31			0.004	0.004	0.092	0.066			0.014	0.012	0.27	0.25		
		Min	0.006	0.006	0.10	0.14			0.000	0.001	0.004	0.033			0.004	0.004	0.06	0.09		
		Stdev	0.003	0.003	0.06	0.05			0.001	0.001	0.027	0.010			0.003	0.002	0.06	0.05		
		N	12	11	12	11			12	10	12	10			12	10	12	10		

Exhibit 4-29
Porta-PSTA Mass Balance Phosphorus Data Summary

		Time-	TP (mg/L)		Inflow	Outflow	Avg_flow	q_in	q_out	q_avg	MB_TP (g/m2/y)		Removal		Calc_k (m/yr)		
Treatment	**Date**	**Period**	**Inflow**	**Outflow**	**(m3/d)**	**(m3/d)**	**(m3/d)**	**(cm/d)**	**(cm/d)**	**(cm/d)**	**Inflow**	**Outflow**	**(g/m2/y)**	**(%)**	**C* = 0.001**	**0.005**	**0.010**
1	Apr-1999	M	0.038	0.038	0.28	0.31	0.28	4.58	5.25	4.75	0.632	0.668	-0.036	-6%	0.20	0.22	0.26
1	May-1999	M	0.018	0.016	0.27	0.20	0.22	4.47	3.28	3.65	0.271	0.220	0.051	19%	1.89	2.54	4.46
1	Jun-1999	M	0.029	0.015	0.32	0.29	0.30	5.28	4.78	5.03	0.557	0.269	0.288	52%	12.59	15.84	23.91
1	Jul-1999	M	0.013	0.017	0.32	0.24	0.28	5.29	3.95	4.62	0.250	0.244	0.006	2%	-4.66	-6.61	-14.15
2	Apr-1999	M	0.045	0.041	0.26	0.32	0.28	4.41	5.31	4.67	0.717	0.712	0.005	1%	1.89	2.09	2.41
2	May-1999	M	0.019	0.022	0.28	0.23	0.25	4.63	3.86	4.24	0.320	0.298	0.022	7%	-2.90	-3.65	-5.41
2	Jun-1999	M	0.035	0.021	0.33	0.39	0.36	5.47	6.44	5.95	0.712	0.489	0.223	31%	11.63	13.78	17.99
2	Jul-1999	M	0.013	0.013	0.31	0.21	0.26	5.23	3.51	4.37	0.253	0.155	0.098	39%	0.72	1.09	2.95
3	Apr-1999	M	0.038	0.029	0.25	0.35	0.27	4.11	5.83	4.54	0.563	0.547	0.016	3%	4.43	5.05	6.14
3	May-1999	M	0.018	0.018	0.29	0.28	0.28	4.86	4.63	4.74	0.330	0.334	-0.003	-1%	0.46	0.60	0.98
3	Jun-1999	M	0.028	0.015	0.29	0.30	0.29	4.89	5.00	4.87	0.517	0.253	0.264	51%	12.17	15.46	23.94
3	Jul-1999	M	0.013	0.014	0.30	0.26	0.28	5.08	4.25	4.66	0.236	0.227	0.009	4%	-1.70	-2.51	-6.24
4	Apr-1999	M	0.039	0.038	0.28	0.36	0.30	4.59	5.97	4.96	0.653	0.704	-0.051	-8%	0.54	0.60	0.70
4	May-1999	M	0.019	0.022	0.28	0.37	0.32	4.69	6.09	5.39	0.319	0.492	-0.174	-54%	-3.24	-4.10	-6.16
4	Jun-1999	M	0.028	0.019	0.32	0.32	0.32	5.40	5.40	5.34	0.537	0.333	0.204	38%	7.65	9.34	12.95
4	Jul-1999	M	0.013	0.015	0.32	0.24	0.28	5.32	4.07	4.70	0.256	0.220	0.036	14%	-2.15	-3.12	-7.20
5	Apr-1999	M	0.039	0.033	0.60	0.68	0.63	9.92	11.41	10.52	1.403	1.317	0.086	6%	6.80	7.69	9.20
5	May-1999	M	0.019	0.021	0.53	0.54	0.54	8.80	9.08	8.94	0.609	0.735	-0.126	-21%	-4.32	-5.50	-8.32
5	Jun-1999	M	0.030	0.014	0.55	0.58	0.56	9.18	9.59	9.39	1.003	0.450	0.553	55%	26.80	34.15	53.81
5	Jul-1999	M	0.013	0.017	0.62	0.58	0.60	10.34	9.59	9.96	0.487	0.568	-0.080	-17%	-10.31	-14.55	-30.50
6	Apr-1999	M	0.038	0.037	0.18	0.24	0.20	3.07	3.95	3.31	0.431	0.474	-0.043	-10%	0.33	0.37	0.44
6	May-1999	M	0.019	0.029	0.19	0.10	0.18	3.20	1.59	3.00	0.241	0.323	-0.083	-34%	-4.79	-5.86	-8.17
6	Jun-1999	M	0.029	0.015	0.44	0.46	0.45	7.37	7.62	7.49	0.766	0.384	0.382	50%	19.34	24.52	37.79
6	Jul-1999	M	0.013	0.013	0.50	0.46	0.48	8.42	7.61	8.02	0.404	0.369	0.035	9%	-0.74	-1.09	-2.73
7	Apr-1999	M	0.040	0.062	0.31	0.26	0.30	5.19	4.30	4.92	0.756	1.138	-0.382	-51%	-8.03	-8.76	-9.88
7	May-1999	M	0.019	0.016	0.29	0.25	0.27	4.91	4.23	4.57	0.337	0.309	0.028	8%	2.65	3.51	5.93
7	Jun-1999	M	0.029	0.027	0.30	0.62	0.46	5.05	10.25	7.65	0.541	0.926	-0.385	-71%	2.17	2.54	3.24
7	Jul-1999	M	0.013	0.013	0.35	0.29	0.32	5.91	4.91	5.41	0.282	0.230	0.052	18%	0.37	0.56	1.51
8	Apr-1999	M	0.037	0.047	0.35	1.58	0.76	5.89	26.40	12.65	0.784	2.042	-1.257	-160%	-10.98	-12.19	-14.13
8	May-1999	M	0.019	0.022	0.28	0.13	0.20	4.58	2.18	3.38	0.318	0.221	0.097	31%	-1.94	-2.44	-3.63
8	Jun-1999	M	0.029	0.019	0.47	0.37	0.42	7.76	6.22	6.99	0.721	0.423	0.298	41%	10.83	13.17	18.14
8	Jul-1999	M	0.013	0.015	0.34	0.22	0.28	5.67	3.74	4.70	0.267	0.220	0.047	18%	-3.02	-4.35	-9.83
9	Apr-1999	M	0.041	0.028	0.37	0.35	0.38	6.25	5.76	6.31	0.930	0.675	0.255	27%	8.58	9.78	11.86
9	May-1999	M	0.019	0.016	0.29	0.19	0.24	4.78	3.18	3.98	0.325	0.173	0.152	47%	2.27	3.01	5.08
9	Jun-1999	M	0.029	0.012	0.32	0.30	0.31	5.37	5.07	5.22	0.537	0.232	0.304	57%	17.44	22.81	40.11
9	Jul-1999	M	0.013	0.014	0.31	0.19	0.25	5.16	3.22	4.19	0.239	0.157	0.082	34%	-1.73	-2.58	-6.62
10	Apr-1999	M	0.036	0.027	0.44	0.28	0.44	7.28	4.68	7.40	1.034	0.818	0.216	21%	7.94	9.14	11.29
10	May-1999	M	0.019	0.015	0.23	0.09	0.18	3.91	1.52	2.94	0.270	0.151	0.119	44%	2.71	3.62	6.27
10	Jun-1999	M	0.029	0.020	0.31	0.29	0.30	5.19	4.85	5.02	0.521	0.376	0.145	28%	6.87	8.31	11.30
10	Jul-1999	M	0.013	0.014	0.31	0.16	0.23	5.09	2.66	3.87	0.247	0.140	0.107	43%	-1.02	-1.48	-3.49
11	Apr-1999	M	0.040	0.063	0.88	0.89	0.88	4.87	4.92	4.88	0.716	1.135	-0.419	-59%	-8.00	-8.72	-9.82
11	May-1999	M	0.020	0.035	0.97	0.79	0.88	5.40	4.37	4.88	0.387	0.749	-0.362	-93%	-10.65	-12.72	-16.92
11	Jun-1999	M	0.027	0.018	1.04	1.00	1.03	5.80	5.56	5.72	0.570	0.370	0.200	35%	9.26	11.49	16.54
11	Jul-1999	M	0.013	0.016	0.97	1.13	1.05	5.39	6.25	5.82	0.255	0.362	-0.106	-42%	-4.07	-5.84	-12.95
12	Apr-1999	M	0.037	0.037	0.97	0.92	0.97	5.40	5.12	5.39	0.712	0.739	-0.026	-4%	-0.18	-0.21	-0.24
12	May-1999	M	0.019	0.023	1.00	1.23	1.11	5.54	6.83	6.18	0.369	0.568	-0.198	-54%	-5.13	-6.44	-9.45
12	Jun-1999	M	0.027	0.018	1.02	0.94	0.99	5.68	5.20	5.47	0.540	0.352	0.188	35%	8.09	10.00	14.29
12	Jul-1999	M	0.013	0.018	1.00	1.07	1.04	5.58	5.95	5.76	0.253	0.385	-0.132	-52%	-7.69	-10.84	-23.04

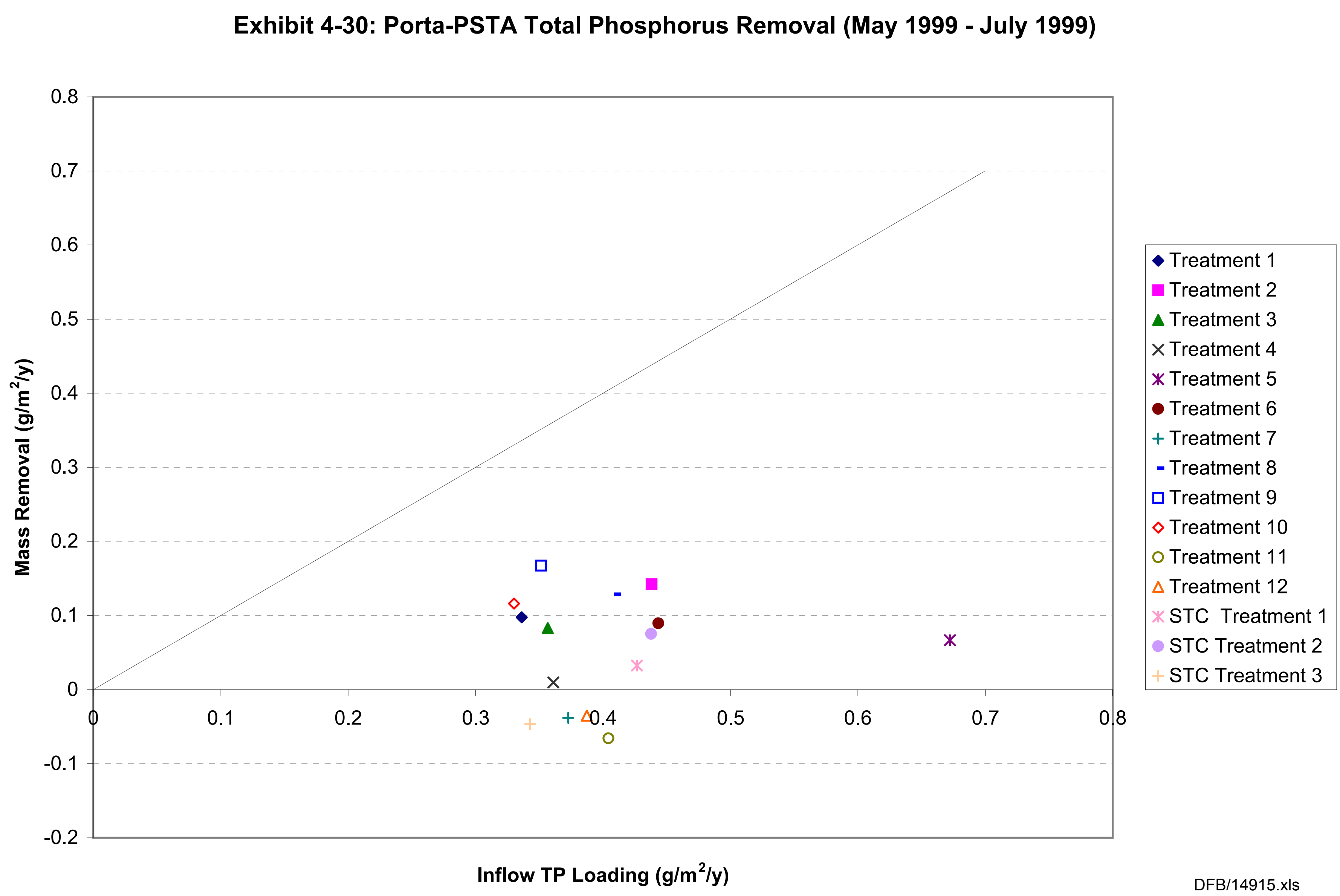
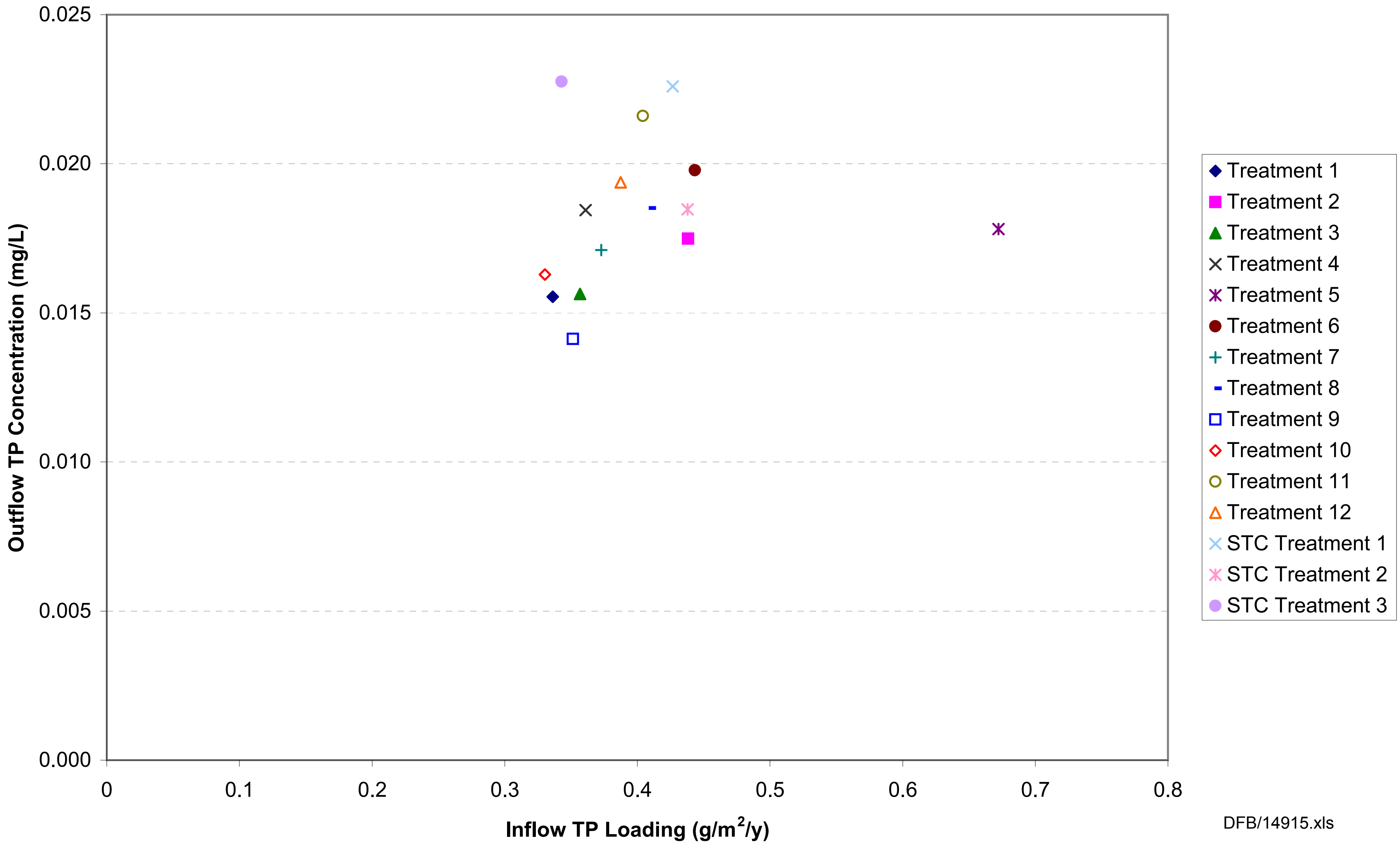


Exhibit 4-30: Porta-PSTA Total Phosphorus Removal (May 1999 - July 1999)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Mass Removal (g/m2/y)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Inflow TP Loading (g/m2/y)
Treatment 1
Treatment 2
Treatment 3
Treatment 4
Treatment 5
Treatment 6
Treatment 7
Treatment 8
Treatment 9
Treatment 10
Treatment 11
Treatment 12
STC Treatment 1
STC Treatment 2
STC Treatment 3
DFB/14915.xls

Exhibit 4-31: Porta-PSTA Total Phosphorus Outflow Concentrations (May 1999 - July 1999)



DFB/14915.xls

4.6.1 Phosphorus

The revised PSTA Research Plan identified an average experimental HLR of 6 cm/d to all treatments with the exception of Treatment 5, which was to receive 12 cm/d, or twice the HLR (CH2M HILL, 1999). Assuming an average influent concentration of 0.040 mg/L, the calculated TP mass loads were expected to average 0.88 g/m^2/y for all treatments but Treatment 5, which was to receive a mass load of 1.75 g/m^2/y.

As shown in Section 3, the Porta-PSTA HLRs were near the target HLR and averaged approximately 5.5 cm/d. Departures from the target HLR can be attributed to operational maintenance, including removal of temporary obstructions of flow to mesocosms by accumulation of algal solids and detritus within inflow structures.

Monthly TP mass loadings to the mesocosms have averaged significantly lower than designed for the project duration, ranging from a maximum of 0.76 g/m^2/y at the onset of field sampling, which most closely resembled the experimental design assumption, to a minimum of 0.3 g/m^2/y in July (Exhibit 4-28). Inflow concentrations of TP from the ENR outflow averaged 0.039 mg/L in April and generally decreased during the summer to a minimum of 0.013 mg/L in July. The low ENR outflow concentrations are attributed to reduction of phosphorus loads from the EAA in response to Best Management Practice implementation, and reduction in ENR hydraulic load by flow diversion during the construction of Cell 5 of STA-1W.

Discussion of the results of this mass balance analysis for this 4th Quarterly Report should be considered preliminary and subject to change, given the initial stages of algal community development within the Porta-PSTA mesocosms. During the fourth quarter, average outflow mass loads by treatment ranged between 0.18 to 0.61 g/m^2/y. Highest mass removals during this period were associated with Treatments 2, 8, and 9, while Treatments 7, 11, and 12 were found to export TP (see Exhibit 4-30). The mass removal for Treatment 5, which has a design mass load nearly twice that of the remaining treatments showed relatively low mass removal.

Outflow mass loads ranged from 0.18 to 0.67 g/m^2/y for individual mesocosms. Among the six replicated treatments, Treatment 1 displayed the lowest within-treatment variation in TP removal, with individual cell averages ranging from 23 percent to 37 percent. Treatment 2 had the highest within-treatment variation in TP removal, with cell averages ranging from 6 percent to 54 percent.

Average quarterly outflow TP concentrations for all cells ranged from 0.014 mg/L for Treatment 9 to 0.023 mg/L for Treatment 11. Preliminary analysis of means between all treatments (Exhibit 4-28) indicated that the treatment means within this range are not anticipated to be statistically significantly different, given the high variance in Treatment 9. This applies as well to outflow concentrations from Treatment 5, which averaged 0.018 mg/L during the quarter even though the loading rate was significantly greater than other treatments (see Exhibit 4-29). Within- and between-treatment variance, as well as experimental effects such as system age, will be fully quantified by analysis of variance (ANOVA) within future reports when sufficient data are available for cost-effective analysis.

The quarterly assessment described above, while expeditious, obscures important seasonal trends in PSTA performance, as quantified by the first-order areal rate constant. Average TP rate constants were calculated from monthly mean concentration data and HLRs using two methods, the k-C* model and the tanks-in-series model. For this analysis, three C* scenarios were assumed with concentrations of 0.001, 0.005, and 0.010 mg/L.

Consistent TP removal was measured across nearly all treatments in June 1999, followed by a measurable decrease in July in response to very low TP inflow loads and concentrations (see Exhibit 4-29, and Appendix A). Average rate constants as high as 25 to 53 m/y were measured in June in Treatment 5, depending upon the C* selected. Removal rate constants were nearly uniformly negative in July, indicating that internal TP loading from sediment releases (apparently from peat oxidation and TP desorption from all sediments) was balancing TP removals via plant production and sediment accretion.

Average inflow TPP mass loads for all treatments ranged from 0.15 to 0.30 $g/m^2/y$. Outflow TPP mass loads ranged from 0.06 to 0.32 $g/m^2/y$. Highest TPP removal was observed in Treatments 2 and 9. Treatments 4, 5, 7, 11, and 12 exported TPP during the current quarter.

4.6.2 Nitrogen

Exhibit 4-32 presents a TN mass balance summary for the 3rd and 4th quarters. Average inflow TN mass loads for all Porta-PSTA treatments combined was 20.6 $g/m^2/y$ during the fourth quarter. Outflow mass loads ranged from 6.1 to 17.6 $g/m^2/y$. All treatments removed TN during the fourth quarter. The average TN mass removal was 9.05 $g/m^2/y$ for the 4th quarter (44 percent), and the average outflow TN concentration was 0.84 mg/L.

4.7 Sediments

Pre-existing and newly deposited soils within the Porta-PSTA mesocosms were cored at randomly selected locations and analyzed from the depth increment 0 to 10 cm. Sub-samples from each of the cores were analyzed, and key parameter analyses are summarized in Exhibit 4-33, and are highlighted as follows.

Temperature: On May 28, 1999, CH2M HILL initiated continuous monitoring of sediment temperature at the Porta-PSTAs. A temperature probe was placed approximately 1 cm into the sediments and rotated between mesocosms on a 3- to 4-day schedule. Exhibit 4-34 presents a time series plot of sediment, air, and water column average temperatures. Average temperatures for each media follow the same pattern; however, air temperature was approximately 2.5°C lower than sediment and water column temperatures during this monitoring period. Sediment and water temperatures were typically very similar.

Bulk Density: Samples were collected monthly from each mesocosm and analyzed for density and percent solids. Bulk density was estimated by multiplying the sample's wet density by the percent solids.

The peat soils in Treatments 1, 3, 9, and 12 are highly organic and exhibit low bulk densities, which averaged 0.27 g/cm^3, compared with the mineral soils of Treatments 2, 4, 5, 6, 7, 8, 10, and 11, which averaged 1.20 g/cm^3. Average bulk density was observed to decrease in Porta-PSTA Treatments 1, 3 through 9, and 12 since initiation of this monitoring.

Exhibit 4-32

Porta-PSTA Total Nitrogen Mass Balance Summary for Third and Fourth Quarters

Site	Treatment	Date	TN (mg/L)		Inflow (m^3/d)	Outflow (m^3/d)	Avg_flow (m^3/d)	q_in (cm/d)	q_out (cm/d)	q_avg (cm/d)	MB_TN ($g/m^2/y$)		Removal	
			Inflow	Outflow							Inflow	Outflow	($g/m^2/y$)	(%)
Porta	1	Qtr-3	1.48	1.04	0.32	0.35	0.33	5.34	5.76	5.55	28.85	21.95	6.90	23.91
Porta	1	Qtr-4	0.93	0.67	0.31	0.18	0.23	5.14	3.05	3.81	16.12	6.06	10.05	62.38
Porta	2	Qtr-3	1.48	0.92	0.29	0.34	0.31	4.83	5.64	5.24	26.11	18.81	7.31	27.98
Porta	2	Qtr-4	0.98	0.79	0.32	0.26	0.29	5.27	4.37	4.82	18.75	11.52	7.23	38.55
Porta	3	Qtr-3	1.48	1.30	0.26	0.31	0.29	4.33	5.20	4.76	23.39	22.23	1.16	4.98
Porta	3	Qtr-4	0.93	0.59	0.32	0.26	0.29	5.33	4.37	4.85	18.20	9.30	8.90	48.90
Porta	4	Qtr-3	1.48	0.99	0.30	0.33	0.32	5.08	5.56	5.32	27.42	19.82	7.60	27.70
Porta	4	Qtr-4	0.95	0.89	0.32	0.29	0.31	5.37	4.83	5.10	18.71	12.71	6.00	32.07
Porta	5	Qtr-3	1.48	0.91	0.57	0.68	0.63	9.54	11.36	10.45	51.56	37.61	13.95	27.06
Porta	5	Qtr-4	0.86	0.66	0.60	0.50	0.55	9.95	8.35	9.15	31.47	17.58	13.89	44.13
Porta	6	Qtr-3	1.48	1.43	0.17	0.19	0.18	2.77	3.24	3.01	14.98	17.48	-2.50	-16.69
Porta	6	Qtr-4	0.96	0.76	0.37	0.34	0.36	6.15	5.75	5.95	22.18	9.91	12.26	55.30
Porta	7	Qtr-3	1.48	1.73	0.32	0.21	0.27	5.37	3.48	4.43	29.01	21.97	7.03	24.25
Porta	7	Qtr-4	0.96	0.66	0.34	0.37	0.35	5.59	6.19	5.89	19.86	12.72	7.14	35.94
Porta	8	Qtr-3	1.48	1.34	0.39	0.29	0.34	6.44	4.80	5.62	34.79	23.48	11.31	32.52
Porta	8	Qtr-4	0.96	0.69	0.34	0.18	0.26	5.61	3.01	4.31	19.88	6.43	13.45	67.66
Porta	9	Qtr-3	1.48	NA	0.37	0.35	0.36	6.16	5.76	5.96	33.28	NA	NA	NA
Porta	9	Qtr-4	0.96	0.82	0.32	0.28	0.30	5.29	4.60	4.94	18.30	13.67	4.63	25.32
Porta	10	Qtr-3	1.48	1.49	0.27	0.29	0.28	4.47	4.80	4.64	24.15	26.10	-1.96	-8.11
Porta	10	Qtr-4	0.93	0.76	0.30	0.16	0.23	4.93	2.66	3.80	16.81	7.13	9.68	57.59
Porta	11	Qtr-3	1.48	1.38	0.90	1.07	0.98	5.01	5.92	5.47	27.06	29.82	-2.76	-10.18
Porta	11	Qtr-4	0.93	0.91	1.04	0.90	0.97	5.81	4.98	5.39	19.82	16.51	3.31	16.71
Porta	12	Qtr-3	1.48	1.59	1.07	0.95	1.01	5.92	5.28	5.60	31.98	30.64	1.34	4.18
Porta	12	Qtr-4	0.97	0.77	1.11	1.09	1.10	6.18	6.08	6.13	21.93	17.71	4.22	19.24

Notes:

NA = Not Available

Exhibit 4-33

PORTA-PSTA Mesocosms Sediment Data Summary

Treatment	Date	Density (g/cm^3)	Solids (%)	Bulk Den (g/cm^3)	Vol Solids (%)	TP (mg/kg)	TIP (mg/kg)	TKN (mg/kg)	TOC (mg/kg)
1	Apr-99	1.17	32	0.37		158.3	103.2		
1	May-99	1.09	32	0.35		180.0	92.7	9600.0	63133.3
1	Jun-99	1.10	15	0.16	65.13	208.9	105.5		
1	Jul-99	1.12	12	0.13		117.0	97.0		
2	Apr-99	1.87	69	1.28		868.3	836.1		
2	May-99	1.78	63	1.12		1052.1	932.5	17.5	1806.0
2	Jun-99	1.83	69	1.27	3.45	804.3	682.6		
2	Jul-99	1.81	71	1.28		1038.4	904.3		
3	Apr-99	1.17	27	0.32		184.2	112.5		
3	May-99	1.12	26	0.30		183.5	88.8	3086.7	27200.0
3	Jun-99	1.07	20	0.21	56.47	205.1	100.1		
3	Jul-99	1.12	17	0.19		277.1	266.0		
4	Apr-99	1.95	67	1.31		903.4	912.1		
4	May-99	1.84	66	1.21		914.1	780.6	13.9	2020.0
4	Jun-99	1.69	78	1.32	3.13	939.8	805.8		
4	Jul-99	1.55	51	0.72		953.2	857.9		
5	Apr-99	1.90	65	1.24		999.7	973.5		
5	May-99	1.86	73	1.35		970.8	840.4	21.7	2045.3
5	Jun-99	1.85	67	1.25	NA	960.4	907.1		
5	Jul-99	1.82	56	1.02		981.0	889.8		
6	Apr-99	1.89	78	1.46		911.7	909.9		
6	May-99	1.80	73	1.31		1001.2	878.5	21.9	1217.7
6	Jun-99	1.86	75	1.39	NA	934.7	901.3		
6	Jul-99	1.79	48	0.84		922.4	864.4		
7	Apr-99	1.86	77	1.43		16.6	13.1		
7	May-99	1.80	77	1.39		12.0	7.9	5.0	33.6
7	Jun-99	1.86	70	1.30	1.00	31.9	22.1		
7	Jul-99	1.76	67	1.18		23.8	12.7		
8	Apr-99	1.86	70	1.30		19.7	16.1		
8	May-99	1.75	34	0.60		11.9	10.3	2.0	1770.0
8	Jun-99	1.84	81	1.50	0.00	20.7	13.3		
8	Jul-99	1.36	51	0.69		12.0	13.0		
9	Apr-99	1.08	24	0.26		206.3	104.7		
9	May-99	1.15	28	0.32		182.5	94.2	2300.0	69700.0
9	Jun-99	1.11	27	0.30	42.50	203.6	90.4		
9	Jul-99	1.04	13	0.14		127.7	97.1		
10	Apr-99	1.94	66	1.28		1060.0	987.3		
10	May-99	1.86	77	1.43		918.1	823.7	19.4	1850.0
10	Jun-99	1.84	64	1.18	2.00	1025.2	892.7		
10	Jul-99	1.88	74	1.39		1098.8	965.6		
11	Apr-99	1.88	72	1.35		972.9	968.6		
11	May-99	1.75	78	1.37		969.2	991.3	34.5	26000.0
11	Jun-99	1.85	77	1.42	4.40	897.1	841.1		
11	Jul-99	1.84	82	1.51		887.3	785.4		
12	Apr-99	1.16	27	0.31		219.2	133.7		
12	May-99	1.14	39	0.44		184.3	93.4	5410.0	34200.0
12	Jun-99	1.03	19	0.19	61.00	196.7	107.4		
12	Jul-99	1.08	27	0.29		138.6	124.4		

Note:
NA = Not Available

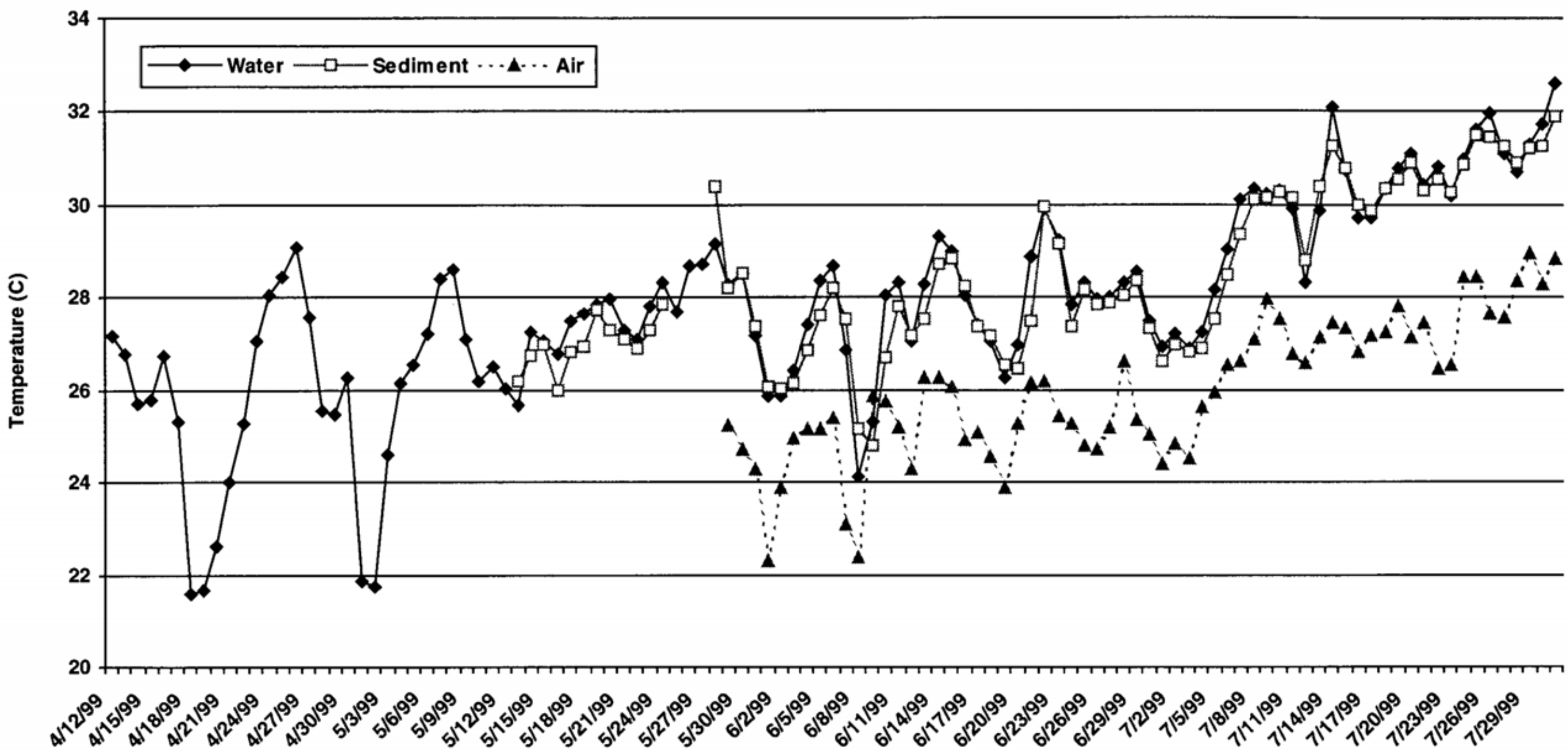


EXHIBIT 4-34
Sediment, Air, and Water Column Temperature Comparison in the Porta-PSTAs (Daily Averages)

Phosphorus: Sediment samples were collected monthly from the Porta-PSTAs and analyzed for TP and TIP monthly and quarterly for NRP. NRP analyses for sediment samples collected this quarter are not yet available from the analytical laboratory; these will be incorporated into the next quarterly report. Treatments 7 and 8 (sand) exhibited the lowest average TP concentration at the Porta-PSTA site varying between 11.9 and 31.9 mg/kg with an average TIP concentration between 7.9 and 22.1 mg/kg. Monthly TP and TIP concentration trends in these samples are variable. Soil TP averaged 2.75 and 1.80 g/m^2 in the sand treatments.

In Treatments 1, 3, 9, and 12 (peat), the average TP concentration has varied between 117 and 277 mg/kg with an average TIP concentration between 88.8 and 266 mg/kg. Monthly TP and TIP concentration trends in these samples are variable. Soil TP averaged between 4.40 and 5.71 g/m^2 in the peat soil mesocosms.

In Treatments 2, 4, 5, 6, 10, and 11 (shellrock), the average TP concentration varied between 804 and 1,099 mg/kg, with an average TIP concentration between 683 and 991 mg/kg. Monthly TP and TIP concentration trends in these samples are variable. Soil TP averaged between 106 and 135 g/m^2 in the shellrock soil mesocosms.

Nitrogen: TKN was sampled quarterly from the Porta-PSTAs. The sandy soils of Treatments 7 and 8 exhibited an average TKN concentrations varying from 2.0 to 5.0 mg/kg. Shellrock treatments 2, 4, 5, 6, 10, and 11 displayed slightly higher concentrations, ranging from 13.9 to 34.5 mg/kg. In contrast to the sand and shellrock soils, peat soils in Treatment 1, 3, 9, and 12 displayed greater average TKN measurements ranging from 2,300 to 9,600 mg/kg.

Total Organic Carbon: TOC was sampled quarterly from the Porta-PSTAs. The sandy soils of Treatments 7 and 8 exhibited average TOC concentrations varying from 33.6 to 1,770 mg/kg. Treatments 2, 4, 5, 6, 10, and 11 (shellrock) average TOC concentrations ranged from 1,218 to 26,000 mg/kg. In comparison to the mineral soils, the peat soils of Treatments 1, 3, 9, and 12 exhibited the greatest averaged TOC, concentrations varying from 27,200 to 69,700 mg/kg.

4.8 Biological Analyses

Algal and macrophytic plant communities are being closely monitored in the Porta-PSTAs. The indices chosen for these studies are intended to characterize the changes in these communities over time and to contrast the effects of experimental treatments on them. Measured parameters include percent cover, macrophyte stem counts, biomass, species composition, algal cell counts and biovolumes, chlorophyll, and nutrient content with an emphasis on phosphorus. In addition to these population-level studies, ecosystem-level response is being estimated using DO dynamics as an indicator of community metabolism.

4.8.1 Plant Cover

Plant cover in the Porta-PSTAs is estimated visually on a monthly basis. The method is the same as described in Section 3.7.1. Cover is estimated in three zones demarcated by the transverse reinforcement straps that cross each mesocosm. Values from these three zones are averaged to provide an estimate of cover for each mescosom.

Exhibit 4-35 summarizes the plant cover estimates for the Porta-PSTAs for the first two quarters of operation. Data are presented by treatment number. Average total plant cover has increased dramatically in Treatments 3, 7, 11, and 12 during the period of operation.

This cover is dominated by emergent macrophytes in Treatments 3 and 12, with 28.5 and 38.8 percent macrophyte cover estimated in July. This macrophyte cover is primarily spike-rush. These treatments are both shallow peat-based systems. The deep peat-based meso-cosms (Treatment 1) are also growing spikerush but not nearly as fast (9.4 percent cover in July). Other emergent macrophyte species have been pulled from the Porta-PSTAs. Species that have volunteered include cattails, chara, and southern naiad (*Najas guadalupensis*).

The relatively high plant cover observed in Treatments 7 and 11 in July is the result of the presence of floating blue-green algal mats. Treatment 7 is a shallow sand control while Treatment 11 is a shallow shellrock control. Significant floating blue-green mats were also observed in Treatments 3, 4, 6, and 8 in July.

4.8.2 Macrophyte Stem Counts

Stems of spikerush have been counted monthly in the Porta-PSTAs since these tanks were planted in April. Average stem counts (stems/m^2) in July by treatment were:

1. 10.2
2. 2.2
3. 226
4. 8.1
5. 6.4
6. 4.7
7. 1.2
8. 0.8
9. 0
10. 0
11. 7.4
12. 183

Greatest stem densities were observed in the shallow peat-based mesocosms (226 stems/m^2 in Treatment 3 and 183 stems/m^2 in Treatment 12). Deeper peat-based mesocosms had fewer stems (10.2 stems/m^2 in Treatment 1). Shallow shellrock treatments had slightly higher average stem densities than deeper mesocosms (8.1 stems/m^2 in the 30-cm tanks and 2.2 to 6.4 stems/m^2 in the 60-cm deep tanks). Stem counts were very low in the sand-based controls 0.8 and 1.2 stems/m^2) and were zero in the aquashade controls where spikerush was not introduced. A few young cattails were pulled from one of the aquashade control tanks (Treatment 9) during this quarter.

4.8.3 Periphyton Community

Periphyton cores are collected from the Porta-PSTAs on a monthly basis. A single sample is collected from a randomly-selected location in the mesocosm and analyzed separately. The methods for sampling are the same as those described in Section 3.7.2. As in the Test Cells, it is difficult to sample the benthic algae in the Porta-PSTAs without incorporating an unwanted and unquantified amount of soil in the samples. This problem was particularly acute at the beginning of the project before development of a relatively discrete benthic algal mat. All periphyton data must be evaluated with this sampling difficulty in mind. All biomass samples include a component of soil; however, the nature of this soil is very different between the shellrock, peat, and sand treatments, and the proportion of soil in these samples has declined during the period of study.

Exhibit 4-35

Summary of Algae and Macrophyte Percent Cover Estimates in the Porta-PSTA Mesocosms, April to July 1999

Treatment	Date	Blue-Green Algal Mat	Green Algal Mat	Emergent Macrophytes	Floating Aquatic Plants	Submerged Aquatic Plants	Macrophyte % Cover	Total % Cover
1	Apr-99	0.0%	0.0%	1.0%	0.0%	3.0%	4.0%	4.0%
1	May-99	0.3%	0.0%	2.3%	0.0%	1.3%	3.7%	4.0%
1	Jun-99	0.0%	0.0%	2.1%	0.0%	3.0%	5.1%	5.1%
1	Jul-99	0.1%	0.2%	3.8%	0.0%	5.5%	9.4%	9.6%
2	Apr-99	0.2%	0.0%	1.2%	0.0%	3.0%	4.2%	4.3%
2	May-99	0.3%	0.0%	1.7%	0.0%	1.3%	3.0%	3.3%
2	Jun-99	0.0%	0.0%	2.2%	0.0%	0.3%	2.6%	2.6%
2	Jul-99	0.9%	0.1%	0.6%	0.0%	0.6%	1.1%	2.1%
3	Apr-99	1.0%	0.0%	5.6%	0.0%	5.3%	10.9%	11.9%
3	May-99	1.0%	0.3%	14.5%	0.0%	2.3%	16.8%	18.2%
3	Jun-99	0.4%	0.3%	28.8%	0.0%	2.3%	31.1%	31.9%
3	Jul-99	4.0%	2.8%	25.8%	0.0%	2.7%	28.5%	35.3%
4	Apr-99	1.8%	0.0%	2.0%	0.0%	4.6%	6.6%	8.4%
4	May-99	1.0%	0.0%	2.3%	0.0%	1.0%	3.3%	4.3%
4	Jun-99	0.1%	0.3%	1.7%	0.0%	0.0%	1.7%	2.1%
4	Jul-99	11.5%	0.7%	0.9%	0.0%	0.0%	0.9%	13.1%
5	Apr-99	4.3%	0.0%	1.1%	0.3%	2.1%	3.6%	7.9%
5	May-99	0.7%	0.0%	1.7%	0.0%	2.0%	3.7%	4.3%
5	Jun-99	0.0%	0.0%	2.7%	0.0%	0.3%	3.0%	3.0%
5	Jul-99	0.5%	0.3%	0.8%	0.0%	0.0%	0.8%	1.6%
6	Apr-99	2.3%	0.0%	3.0%	0.0%	2.0%	5.0%	7.3%
6	May-99	1.7%	0.0%	1.7%	0.0%	0.7%	2.3%	4.0%
6	Jun-99	0.0%	0.0%	1.4%	0.0%	0.0%	1.4%	1.4%
6	Jul-99	6.7%	0.0%	1.8%	0.0%	1.3%	3.1%	9.8%
7	Apr-99	1.0%	0.0%	0.7%	0.7%	3.0%	4.3%	5.3%
7	May-99	1.0%	0.0%	1.0%	0.0%	1.0%	2.0%	3.0%
7	Jun-99	0.0%	0.0%	0.3%	0.0%	0.0%	0.3%	0.3%
7	Jul-99	24.2%	0.0%	0.7%	0.0%	0.0%	0.7%	24.8%
8	Apr-99	1.0%	0.0%	0.7%	0.0%	3.0%	3.7%	4.7%
8	May-99	1.0%	0.0%	1.0%	0.0%	3.0%	4.0%	5.0%
8	Jun-99	0.0%	0.0%	0.7%	0.0%	0.0%	0.7%	0.7%
8	Jul-99	9.3%	1.0%	0.7%	0.0%	0.0%	0.7%	11.0%
9	Apr-99	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	May-99	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	Jun-99	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	Jul-99	1.0%	0.0%	0.3%	0.0%	3.0%	3.3%	4.3%
10	Apr-99	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10	May-99	0.0%	0.0%	3.0%	0.0%	0.0%	3.0%	3.0%
10	Jun-99	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10	Jul-99	0.3%	0.0%	0.0%	0.0%	1.0%	1.0%	1.3%
11	Apr-99	1.7%	0.0%	3.0%	0.0%	0.0%	3.0%	4.7%
11	May-99	1.0%	0.0%	3.0%	0.0%	0.0%	3.0%	4.0%
11	Jun-99	1.0%	1.0%	2.3%	0.0%	0.0%	2.3%	4.3%
11	Jul-99	17.5%	0.0%	3.0%	0.0%	0.0%	3.0%	20.5%
12	Apr-99	0.0%	0.0%	7.5%	0.0%	17.5%	25.0%	25.0%
12	May-99	0.0%	0.0%	7.5%	0.0%	1.0%	8.5%	8.5%
12	Jun-99	0.0%	0.0%	30.8%	0.0%	0.0%	30.8%	30.8%
12	Jul-99	0.0%	0.0%	37.5%	0.0%	1.3%	38.8%	38.8%

Exhibit 4-36 summarizes periphyton sample data for the Porta-PSTAs since the beginning of the study. Biomass numbers must be interpreted in light of the cautions described above. The peat soils in Treatments 1, 3, 9, and 12 are highly organic, and their occurrence in samples is demonstrated by the very high ash free dry weights recorded for these treatments. The fraction of this material sampled was reduced but not eliminated in the July samples. Biomass estimates for Treatments 9 and 10 can be used as approximate controls of the amount of soil incorporated in samples because these treatments received aquashade and had minimal benthic periphyton colonization. Ash weights for these samples indicate a fairly large mineral residue. The proportion of this ash that is calcium is similar between substrate type and generally ranged from 12 to 26 percent in the July samples.

Estimated periphyton ash free dry weight biomass in the July samples ranged from 82 to 487g/m^2 in all treatments. Total and inorganic phosphorus and TKN concentrations measured in these samples were variable. The typical range of TP concentrations in these samples was from 224 to 1,765 mg/kg dry weight. Periphyton TP concentrations were typically slightly higher in the shellrock treatments than in the peat treatments. The two sand treatments had lower periphyton TP concentrations. TKN concentrations ranged from 896 to 11,357 mg/kg dry weight and were typically much higher in the peat-based mesocosms.

Chlorophyll provides a more direct method of estimation of algal populations in these periphyton samples. Chlorophyll concentrations corrected for phaeophytin, ranged from 14 to 151 mg/m^2 in the July samples.

Detailed algal taxonomy and cell counts are being conducted on all of these periphyton samples. Although incorporated soils sometimes make counting imprecise, these cell numbers and their associated volumes provide the best indicator of actual periphyton community structure.

Exhibit 4-36 also summarizes the cell counts and number of identified taxa by algal group. Average total cell counts generally increased in all treatments during the period from startup in April until the July samples. In July total cell counts ranged from 2.4 to 334 x 10^9 per m^2 with an average of 25 to 42 taxa represented in the counts. The lowest cell counts were encountered in the aquashade controls. Blue-green algae clearly dominate the cell counts in these mesocosms except in Treatments 9 and 10 (aquashade controls). Diatoms and green algae comprise a significant fraction of the cell counts from the aquashade treatments.

The average algal biovolume in these samples was between 1.6 and 65.4 cm^3/m^2. The July SWDI varied from 2.9 and 4.4 units, and evenness ranged between 0.61 and 0.83.

4.9 Ecosystem Metabolism

Exhibit 4-37 summarizes the ecosystem metabolism estimates for the Porta-PSTAs by operational quarter. CM of the Porta-PSTA ecosystems was variable during the period of this research. Fourth quarter average CM estimates ranged from 0.67 to 3.9 g $O_2/m^2/d$. The overall average NPP in the Porta-PSTAs was 0.235 g $O_2/m^2/d$ for the period-of-record. Based on a time period of approximately 129 days, this average net production should result in an average plant biomass of approximately 60 g afdw/m^2. This estimate is considerably less than the average July periphyton core estimate of 285 g afdw/m^2.

Exhibit 4-36

Summary of Periphyton Data from the Porta-PSTA Mesocosoms, April to July 1999

		Periphyton Biomass (g/m^2)			Ca	Chl_a (corr)	Phaeo.	TP	TIP	TKN	Blue Green Algae		Diatoms		Green Algae		Other taxa		Total taxa		Biovolume	Evenness	SWDI
Treat-ment	Date	Ash Wt	Dry Wt	AFDW	(g/m^2)	(mg/m^2)	(mg/m^2)	(g/m^2)	(g/m^2)	(g/m^2)	($10^6 cell/m^2$)	(# taxa)	($10^6 cell/m^2$)	(# taxa)	($10^6 cell/m^2$)	(# taxa)	($10^6 cell/m^2$)	(# taxa)	($10^6 cell/m^2$)	(# taxa)	(cm^3/m^2)		
1	Apr-99	248.1	613.3	365.2	106.4	23.64	7.39	0.269	0.092		3589	7.0	1205	16.5	154	5.0	8	0.5	4956	29.0		0.669	3.3
1	May-99	695.8	1526.0	829.9	138.9	156.69	76.46	0.487	0.179	8.57	7794	8.3	2823	21.3	443	4.0	53	1.3	11112	35.0	6.57	0.727	3.7
1	Jun-99	329.0	520.0	191.0	28.3	25.31	9.48	0.110	0.026		3880	8.3	1082	18.0	262	3.7	12	0.7	5236	30.7	3.64	0.684	3.4
1	Jul-99	383.3	572.2	188.8	47.9	37.33	2.78	0.077	0.017		46058	14.0	2781	16.3	921	3.7	0	0.0	49761	34.0	4.81	0.741	3.7
2	Apr-99	100.9	120.0	19.1	83.5	16.67	0.29	0.174	0.084		7026	12.5	1824	11.5	409	7.0	11	0.5	9270	31.5		0.787	3.9
2	May-99	475.0	789.5	312.2	72.5	32.79	0.73	0.230	0.185	1.02	21203	11.0	3737	14.0	546	5.0	11	0.5	25497	30.5	10.12	0.752	3.7
2	Jun-99	445.2	543.6	98.3	83.4	29.47	0.36	0.263	0.136		37138	12.7	2673	11.7	187	2.7	19	0.3	40018	27.3	8.05	0.593	2.9
2	Jul-99	1174.5	1458.8	296.8	305.7	150.56	2.48	0.931	0.306		86039	16.0	4504	13.0	1947	7.3	5	0.3	92495	36.7	65.40	0.696	3.6
3	Apr-99	305.6	864.7	559.1	106.1	27.96	16.20	0.385	0.106		1726	5.0	1173	20.3	392	5.3	11	0.7	3302	28.0		0.722	3.5
3	May-99	491.9	1250.9	758.9	67.2	118.07	32.36	0.305	0.096	4.57	5408	8.3	3052	22.3	344	5.0	8	0.3	8811	36.0	7.13	0.759	3.9
3	Jun-99	248.8	521.5	272.7	77.1	74.17	14.30	0.212	0.029		5153	11.3	1864	23.7	43	2.3	14	0.7	7075	38.0	5.83	0.749	3.9
3	Jul-99	424.5	973.7	549.2	98.6	48.24	11.61	0.355	0.076		9081	10.3	962	16.7	120	2.7	12	0.7	10175	30.3	4.78	0.644	3.2
4	Apr-99	163.1	190.0	26.9	81.1	25.58	0.16	0.238	0.035		8048	9.3	2232	9.3	409	5.7	3	0.3	10692	24.7		0.776	3.5
4	May-99	313.4	482.8	169.5	65.3	39.13	0.67	0.252	0.173	0.80	17891	13.0	3870	12.3	203	4.3	0	0.0	21964	29.7	11.43	0.731	3.6
4	Jun-99	329.1	425.1	96.0	120.4	77.49	0.21	0.309	0.109		43914	13.3	3409	11.7	772	2.7	0	0.0	48094	27.7	14.37	0.651	3.1
4	Jul-99	654.2	778.8	124.7	97.9	50.83	0.19	0.640	0.005		66103	12.0	1925	11.0	746	3.3	0	0.0	68774	26.3	7.80	0.619	2.9
5	Apr-99	136.3	160.2	23.9	93.9	26.89	0.32	0.232	0.077		10242	4.7	1929	11.7	387	3.7	3	0.7	12561	23.0		0.774	3.5
5	May-99	557.9	836.4	277.2	100.9	20.49	0.35	0.351	0.285	0.81	26216	13.0	1427	11.0	432	6.0	3	0.3	28078	30.3	5.43	0.783	3.9
5	Jun-99	575.5	694.5	119.0	155.1	42.22	0.35	0.460	0.084		44774	13.7	3111	10.0	343	3.3	10	0.3	48212	27.3	8.74	0.754	3.6
5	Jul-99	792.4	953.0	161.7	180.6	58.38	9.76	0.618	0.083		60679	12.0	2170	11.7	975	4.3	10	0.3	63834	28.3	7.49	0.701	3.4
6	Apr-99	86.8	102.2	15.4	48.1	11.23	5.56	0.132	0.041		12485	10.7	1825	14.3	171	5.3	4	0.3	14485	29.3		0.740	3.6
6	May-99	263.3	340.3	76.9	50.2	28.32	0.15	0.182	0.105	0.69	30266	15.3	3161	14.0	732	4.3	9	0.3	34168	34.0	8.53	0.765	3.9
6	Jun-99	711.9	889.7	177.8	165.6	68.92	0.36	0.678	0.414		79733	15.0	4971	15.0	864	3.3	0	0.0	85568	33.3	15.97	0.656	3.3
6	Jul-99	737.6	910.6	173.0	169.9	70.03	7.32	0.472	0.047		57497	16.7	4582	13.0	1089	3.7	6	0.3	63175	33.7	11.10	0.732	3.7
7	Apr-99	36.3	46.5	10.2	39.6	13.21	0.36	0.082	0.012		18421	6.0	2242	15.0	1428	8.0	0	0.0	22091	31.0		0.590	2.9
7	May-99	398.4	506.7	108.3	43.1	49.71	0.37	0.166	0.026	1.19	61320	16.0	6555	16.0	1847	7.0	0	0.0	69723	39.0	14.91	0.677	3.6
7	Jun-99	221.2	298.8	77.6	38.3	95.77	0.16	0.168	0.014		84484	19.0	8846	12.0	3333	4.0	0	0.0	96664	35.0	15.02	0.838	4.3
7	Jul-99	345.4	459.2	113.8	49.1	107.42	2.12	0.153	0.012		118804	21.0	9879	14.0	3336	7.0	0	0.0	132019	42.0	39.69	0.816	4.4
8	Apr-99	32.0	46.2	14.1	43.5	12.44	4.62	0.048	0.008		8134	10.0	3527	15.0	628	1.0	0	0.0	12289	33.0		0.765	3.9
8	May-99	311.0	414.9	103.9	30.7	46.96	4.48	0.116	0.026	1.15	54304	11.0	5146	13.0	2997	11.0	0	0.0	62446	35.0	16.80	0.511	2.6
8	Jun-99	510.6	654.7	144.1	47.8	53.68	0.37	0.179	0.018		161180	18.0	5035	13.0	1199	3.0	0	0.0	167414	34.0	17.76	0.711	3.6
8	Jul-99	648.8	828.8	179.9	77.9	150.17	32.80	0.323	0.034		297444	22.0	7283	11.0	28675	3.0	227	1.0	333629	37.0	36.44	0.780	4.1
9	Apr-99	575.2	1697.7	1122.5	250.8	22.39	0.28	0.593	0.188		10691	2.0	1795	13.0	299	5.0	0	0.0	12786	16.0		0.503	2.0
9	May-99	860.1	2084.9	1224.8	167.1	200.87	129.56	0.664	0.250	23.68	0	0.0	560	21.0	7	1.0	7	1.0	574	23.0	0.75	0.905	4.1
9	Jun-99	1119.6	2817.2	1697.5	296.2	72.16	33.95	1.085	0.052		0	0.0	853	19.0	0	0.0	0	0.0	853	19.0	1.16	0.902	3.8
9	Jul-99	385.2	732.1	346.9	67.6	29.00	30.07	0.162	0.046		573	2.0	1238	24.0	559	3.0	0	0.0	2370	29.0	1.60	0.805	3.9
10	Apr-99	198.1	224.7	26.6	120.5	13.82	0.37	0.293	0.241		3939	6.0	1623	15.0	258	5.0	0	0.0	5820	26.0		0.662	3.1
10	May-99	729.4	1308.5	573.5	93.7	27.89	0.36	0.353	0.260	1.17	14703	9.0	4536	15.0	1608	4.0	0	0.0	20847	28.0	11.65	0.785	3.8
10	Jun-99	445.7	551.5	105.8	79.7	24.35	0.36	0.251	0.054		3696	9.0	4567	21.0	1191	8.0	0	0.0	9455	38.0	11.95	0.856	4.5
10	Jul-99	578.1	705.5	127.4	121.5	25.87	3.20	0.391	0.162		2273	7.0	1295	20.0	385	5.0	0	0.0	3954	32.0	1.87	0.831	4.2
11	Apr-99	182.9	210.5	27.6	103.4	15.50	0.18	0.331	0.131		3391	9.0	584	15.0	136	6.0	10	1.0	4121	30.0		0.718	3.5
11	May-99	310.5	383.8	73.3	47.4	8.28	0.28	0.186	0.138	0.76	6314	11.0	1114	11.0	245	5.0	0	0.0	7673	27.0	3.92	0.830	3.9
11	Jun-99	1034.5	1191.1	156.6	284.1	24.77	0.18	1.249	0.853		4447	11.0	789	7.0	176	2.0	0	0.0	5412	20.0	2.40	0.811	3.5
11	Jul-99	417.3	499.0	81.7	0.2	13.88	8.89	0.375	0.199		9705	12.0	971	8.0	170	5.0	0	0.0	10845	25.0	3.34	0.646	3.0
12	Apr-99	312.3	857.2	544.9	117.6	22.19	5.78	0.320	0.108		1214	3.0	733	21.0	93	5.0	27	1.0	2068	31.0		0.618	3.1
12	May-99	1057.1	2970.4	1910.4	194.8	53.88	7.78	0.667	0.336	19.02	47	1.0	315	19.0	6	1.0	17	2.0	385	23.0	1.09	0.834	3.8
12	Jun-99	264.9	571.0	306.1	59.5	63.44	0.20	0.181	0.054		15223	15.0	2324	19.0	287	2.0	64	1.0	17897	37.0	6.11	0.813	4.2
12	Jul-99	393.7	881.0	487.3	83.9	38.73	12.07	0.285	0.075		6493	9.0	1140	15.0	26	2.0	0	0.0	7659	26.0	1.87	0.614	2.9

Notes:

Periphyton Biomass (g/m2): [Weight (mg/L)] * [Total Sample Volμme (mL) / ((# Small Cores * 12.4 (cm2)) * 0.01]

Ca (g/m2): Ca (mg/L) * [Total Sample Volμme (mL) / ((# Small Cores * 12.4 (cm2)) * 0.01]

Chlorophyll (mg/m2): Chlorophyll (μg/L) * [Total Sample Volμme (mL) / ((# Small Cores * 12.4 (cm2)) * 0.01]

Biovolμme (cm3/m2): [Biovolμme (μm3/ml)] * 10-6 * [Total Sample Volμme (mL) / ((# Small Cores * 12.4 (cm2)) * 0.01]

Taxa (# cells/m2)*106: (Taxa (# cells/ml) * 106 * [Total Sample Volμme (mL) / ((# Small Cores * 12.4 (cm2)) * 0.01]) / 106

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Exhibit 4-37

Summary of Ecosystem Metabolism for the Porta-PSTA Mesocoms, February to July 1999

Treatment	Time Period	NPP (day) $gO_2/m^2/d$	GPP (day) $gO_2/m^2/d$	CR (24hr) $gO_2/m^2/d$	CM (24hr) $gO_2/m^2/d$	NPP (24hr) $gO_2/m^2/d$	Avg Night Res $gO_2/m^2/hr$	PAR (24hr) $E/m^2/d$	Efficiency %
1	Qtr-3	0.26	1.75	2.41	1.75	-0.66	0.10	41.4	0.81
1	Qtr-4	1.44	3.91	3.96	3.91	-0.05	0.17	43.1	1.74
2	Qtr-3	0.20	0.28	0.97	0.28	1.15	0.04	34.9	0.16
2	Qtr-4	1.39	2.67	1.92	2.67	0.75	0.08	36.5	1.40
3	Qtr-3	0.50	2.20	2.75	2.20	-0.56	0.11	35.8	1.17
3	Qtr-4	0.27	1.44	1.87	1.44	-0.43	0.08	40.7	0.68
4	Qtr-3	1.85	2.97	1.82	2.97	1.15	0.08	41.5	1.37
4	Qtr-4	1.34	2.58	1.90	2.58	0.68	0.08	36.5	1.35
5	Qtr-3	0.97	2.28	2.15	2.28	0.14	0.09	49.4	0.88
5	Qtr-4	1.62	3.62	3.03	3.62	0.59	0.13	44.1	1.57
6	Qtr-3	2.04	3.57	2.49	3.57	1.07	0.10	43.7	1.56
6	Qtr-4	1.05	2.15	1.69	2.15	0.47	0.07	34.8	1.19
7	Qtr-4	2.07	3.52	2.22	3.52	1.30	0.09	35.7	1.89
8	Qtr-4	1.31	2.01	1.08	2.01	0.93	0.05	33.4	1.15
9	Qtr-3	-0.12	0.12	1.76	0.12	-1.25	0.07	41.6	0.06
9	Qtr-4	-0.45	0.67	1.69	0.67	-1.03	0.07	36.7	0.35
10	Qtr-3	0.10	0.22	1.34	0.22	0.16	0.06	38.5	0.11
10	Qtr-4	0.22	1.37	1.77	1.37	-0.40	0.07	50.5	0.52
11	Qtr-4	1.69	2.71	1.59	2.71	1.12	0.07	40.0	1.29
12	Qtr-4	0.19	1.95	2.66	1.95	-0.71	0.11	47.2	0.79

Note: Efficiency is calculated with above-water PAR and the assumption that 1 gO_2/m^2 equals 10 kcal and 1 Einstein (E) of photons equals 52.27 kcal.

NPP estimates for the peat-based treatments were typically negative. These data indicate a net consumption of oxygen in the peat-based tanks and may be an indication of a high sediment oxygen demand. This would not be surprising in light of the highly organic soils in these treatments. The overall average NPP of the aquashade controls were -1.136 g $O_2/m^2/d$ for Treatment 9 (peat) and 0.045 g $O_2/m^2/d$ for Treatment 10 (shellrock). Using the estimate for Treatment 9 as a correction factor for the other peat-based mesocosms results in estimated NPP values in the same positive range as the shellrock mesocosms. With this correction, the average daily NPP for all of the non-aquashade Porta-PSTAs is 0.81 g $O_2/m^2/d$ for the 129-day operational period. This NPP is equivalent to an estimated 208 g afdw/m^2, which is much closer to the periphyton core estimate. Photosynthetic efficiency averaged between 0.79 and 1.74 percent in the non-aquashade mesocosms in July.

4.9.1 PAR Extinction

Exhibit 4-38 summarizes the PAR extinction data for the Porta-PSTAs since the project started in April 1999. Monthly average PAR extinction coefficients generally ranged between 0.30 and 5.08 m^{-1}. Extinction coefficients were generally highest in the aquashade controls, and were slightly higher in the peat-based than in the shellrock mesocosms. Extinction measurement difficulties under variable cloud cover contributed to some of the high values recorded in July.

Exhibit 4-38

Summary of PAR Extinction Measurements from the Porta-PSTAs, February to July 1999

		Water Depth	PAR ($\mu mol/m^2/s$)		Z	Ext Coeff
Treatment	Date	(m)	Surface	Bottom	(m)	(m^{-1})
1	Apr-99	0.61	155.9	57.3	0.49	2.03
1	May-99	0.65	1698.3	840.1	0.53	1.34
1	Jun-99	0.59	2174.2	1157.0	0.47	1.33
1	Jul-1999	0.65	2176.0	986.2	0.52	1.52
2	Apr-99	0.61	136.9	69.1	0.49	1.43
2	May-99	0.61	1496.7	841.0	0.49	1.16
2	Jun-99	0.57	2546.7	1492.6	0.45	1.18
2	Jul-99	0.63	2217.3	1596.0	0.51	0.72
3	Apr-99	0.28	220.4	137.0	0.16	2.79
3	May-99	0.28	1490.3	1248.6	0.17	1.01
3	Jun-99	0.22	1228.1	882.1	0.10	2.41
3	Jul-99	0.30	1746.5	1174.2	0.18	2.24
4	Apr-99	0.35	200.6	148.9	0.22	1.39
4	May-99	0.35	1471.8	1209.5	0.23	0.85
4	Jun-99	0.40	2352.0	1643.6	0.22	1.78
4	Jul-99	0.35	2269.7	1464.3	0.22	2.02
5	Apr-99	0.62	312.6	119.2	0.50	1.87
5	May-99	0.62	1325.9	860.8	0.40	1.10
5	Jun-99	0.58	1940.4	762.0	0.48	2.17
5	Jul-99	0.62	2132.1	794.6	0.50	2.29
6	Apr-99	0.33	208.8	160.4	0.20	1.37
6	May-99	0.33	1505.0	1330.0	0.20	0.52
6	Jun-99	0.59	1562.0	773.3	0.46	1.53
6	Jul-99	0.63	2232.7	1050.8	0.50	1.63
7	Apr-99	0.67	276.7	131.7	0.55	1.35
7	Jun-99	0.31	2468.0	2005.0	0.19	1.08
7	Jul-99	0.37	2034.0	590.0	0.24	5.08
8	Apr-99	0.66	300.2	132.7	0.53	1.53
8	May-99	0.67	1605.6	857.2	0.55	1.14
8	Jun-99	0.61	2476.0	1395.6	0.49	1.17
8	Jul-99	0.69	1923.5	938.6	0.57	1.25
9	Apr-99	0.64	275.6	45.2	0.52	3.49
9	May-99	0.61	1263.8	240.4	0.49	3.40
9	Jun-99	0.56	1628.0	399.6	0.44	3.18
9	Jul-99	0.64	1661.8	171.5	0.52	4.36
10	Apr-99	0.64	289.7	48.0	0.52	3.47
10	May-99	0.64	1194.8	241.0	0.52	3.09
10	Jun-99	0.59	1131.2	283.1	0.47	2.95
10	Jul-99	0.65	1495.8	177.1	0.53	4.05
11	Apr-99	0.34	283.5	224.2	0.21	1.10
11	May-99	0.34	1630.7	1382.5	0.21	0.77
11	Jun-99	0.28	2783.0	2652.0	0.16	0.30
11	Jul-99	0.33	1906.5	722.7	0.20	4.75
12	Apr-99	0.37	244.2	165.4	0.24	1.60
12	May-99	0.37	1398.3	1001.7	0.24	1.37
12	Jun-99	0.30	2274.0	1692.5	0.18	1.61
12	Jul-99	0.34	1371.4	768.5	0.21	2.71

Note: Extinction coefficient = ($\ln PAR_{surf}$ - $\ln PAR_{bot}$)/z and z = water depth -.122 m

SECTION 5

Performance Forecast Model Development

The PSTA forecast model, originally conceptualized by Kadlec and Walker (1996) and van der Valk and Crumpton (1997), is being developed in a series of progressively more complex versions using Microsoft® Access as a model platform. Functional attributes of the targeted Level III forecast model have been previously described in the Revised Research Plan (CH2M HILL, 1999a). Progress through the fourth quarter has included setting up the model to utilize arrays of time-dependent external forcing function data, including sunlight, rain, and ET.

5.1 Model Format

5.1.1 Development Strategy

The PSTA Forecast Model is being developed through a series of specific subtasks. Each model version is anticipated to be self-sufficient. Exhibit 5-1 summarizes this approach.

EXHIBIT 5-1
PSTA Forecast Model Versions

Model Version	Major Characteristics
1.0	Converts Dr. Kadlec's initial P spreadsheet model to Access database
1.1	Establishes the water budget model to bring in forcing function time series of temperature and seasonally varying precipitation and evaporation
1.2	Adds photosynthesis-insolation model for algal growth algorithm
1.3	Adds carbonate cycle
1.4	Adds nitrogen model
1.5	Adds macrophyte growth model
1.6–1.9	Reserved for internal revisions to Access platform changes and calibration to available data
2.0	Final PSTA forecast model

5.1.2 Microsoft® Access as the Model Platform

The approach to model development for the PSTA Forecast Model has been predicated on the need to balance model complexity with ease of use. Spreadsheet programs, such as Microsoft® Excel, can meet this generic need for simplicity of use, but the resulting framework can be large and cumbersome and difficult to implement, particularly when model inputs can consist of multiple sets of varying data stretching over lengthy time periods.

To respond to this conflicting requirement, CH2M HILL has proceeded with the development of the PSTA Forecast Model by using Microsoft® Access as the model platform. While Excel has its advantages, Access offers several unique qualities that will ultimately meet the project requirements. These include the following:

- **Ease of Use**. Access is more user-friendly with separate pages or forms for instructions and text descriptions, model parameter inputs, and results. The user does not need to sort through pages of data to find the results of the model run or parameters to change. A click of a button brings a summary to the screen.
- **Greater Efficiency**. Access has the ability to store and utilize a larger amount of data in a smaller amount of space than Excel. Individual model runs can be stored by a unique title and later be easily recalled for comparison to new model runs. Also, increased model complexity and longer simulation periods will not ordinarily take proportionately greater time to complete.
- **Results Readily Apparent**. Excel may "ghost" model runs, showing no change in results despite a change in input, especially when running lengthy models. In Access, the user will see an indicator that the model is running and final results will be completely displayed.
- **Easy-to-Use Input and Output Forms**. The model user does not need to create comparison or result tables. Access contains forms designed to create report-ready result output. Access will generate print-ready tables or figures based on the model run(s) desired.
- **Easy to Modify**. Access can be adapted to incorporate submodels just as easily as Excel. Additional results or inputs are easily added to existing input forms or result reports.
- **Similar Refinements to Excel**. Initial research indicates the tools available to modelers in Excel (i.e., Solver) are also available using Access.

While more time may be required to initially develop an Access-based model, the end result will be a model that is easier to adapt, manipulate, and interpret.

5.2 Model Design

The Version 1.1 PSTA Forecast model is based upon a relatively simple design system. A "Main Menu" form serves as a starting point. Buttons on this page link the different areas of the model together. Input parameters are then manipulated through a single, self-contained table. The values for this table can be viewed or changed through the "Model Variable Inputs" form. Near the bottom, right-hand corner of the form is a button to run the model. Clicking once on this button runs a number of macros and queries. These are the utilities that Access uses to make calculations and tables. For the PSTA model, all calculations that are time-independent are run first and written to tables. From here, the time-dependent calculations are made. The results are written to a single table, and specific values are then pulled into further use in separate tables as needed.

The results can be retrieved from either the Input form, or the Main Menu. The results display all the input parameters, results, and graphs on a single, easily readable form. Future versions will include a provision that allows the user to give a unique name to the model run that will store those results under that name. Results pages will then be developed to allow the user to compare any two model runs.

The functional heart of the model is contained within the queries and macros that run the model. Appendix C summarizes the calculations designed within the queries. For users with little knowledge of Access database programs, it is suggested any changes that are desired be made through the model designer. However, little knowledge of Access is needed to effectively use the model.

Appendix C includes a memorandum with instructions for using the model. Future versions of the model will include updates to this general memorandum.

5.3 Summary

Initial model development tasks have resulted in a well-developed framework that will allow the model to be built in successive stages while maintaining flexibility in model runs. Issues currently being resolved in the fifth quarter include the choice of the algal growth algorithm and a review of the minimum detail necessary to functionally describe PSTA phosphorus and nitrogen cycles. Software-related issues, such as the inclusion of the Solver tool, will need to be resolved to complete the model calibration phase. These key issues will be addressed and incorporated into the model in the fifth quarter. Also, calibration to existing data sets will be undertaken as well as the incorporation of field quantified variables. Fifth quarter progress is expected to lead to a fully developed PSTA Forecast Model.

SECTION 6

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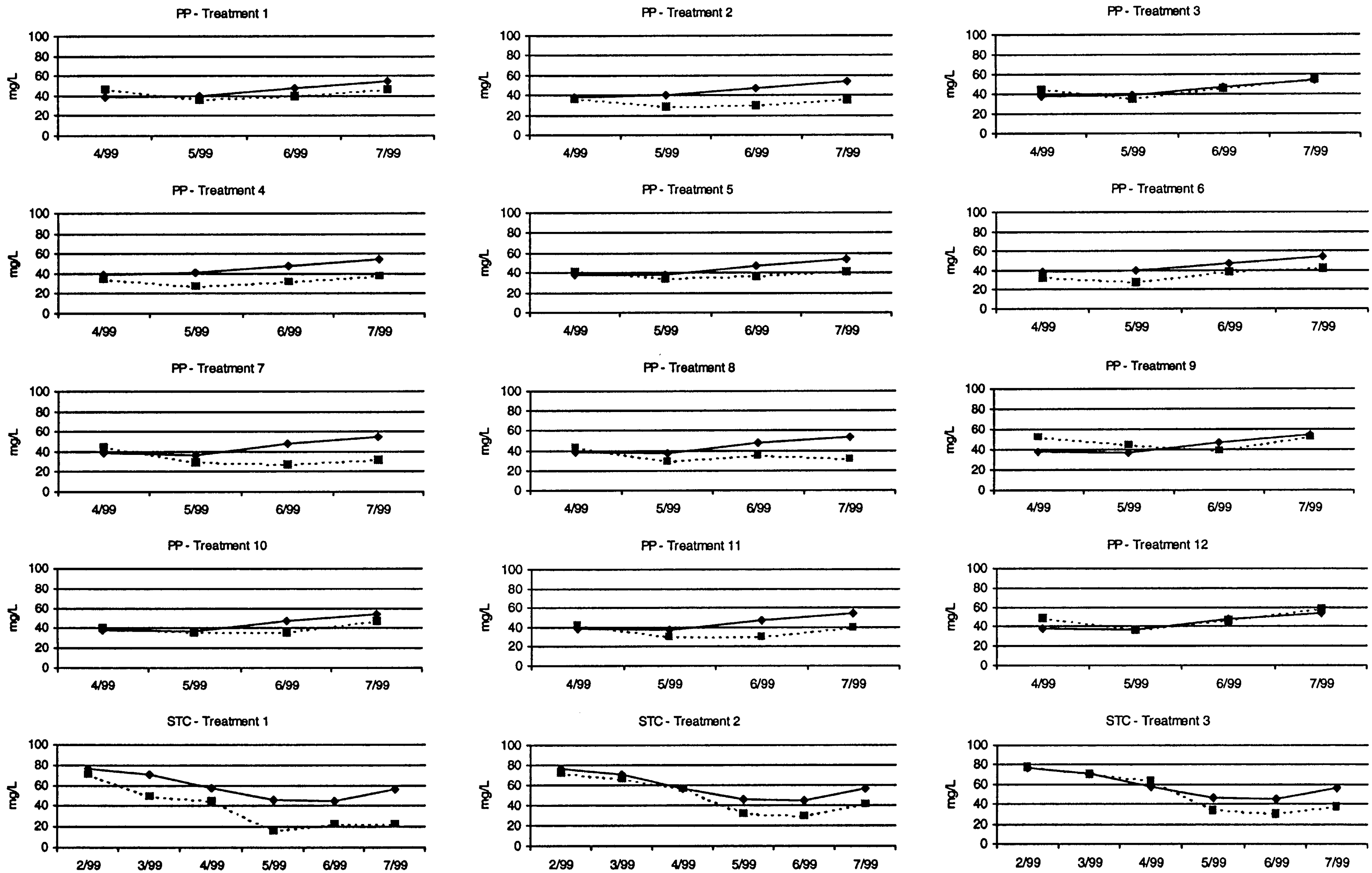
APPENDIX A

Trend charts

SFWMD PSTA Research Project Data Summary
Average Calcium Concentration Trend Charts

Inflow - - ■ - - Outflow



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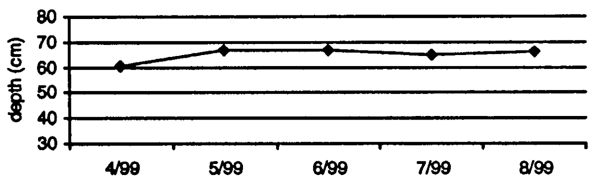
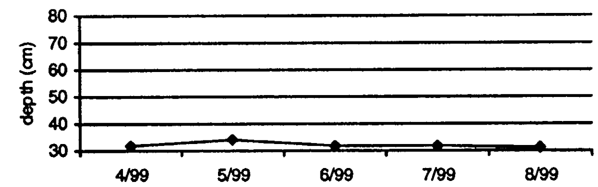
SFWMD PSTA Research Project Data Summary
Average Depth Trend Charts

PP - Treatment 1



PP - Treatment 2

PP - Treatment 3



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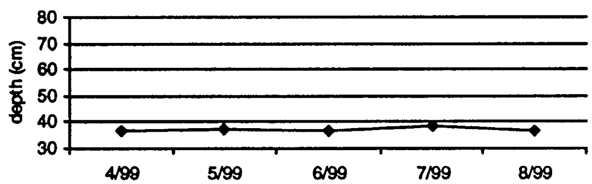

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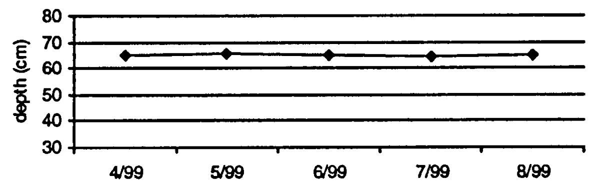
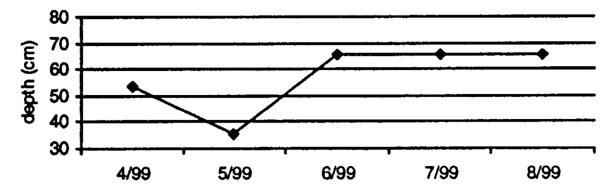
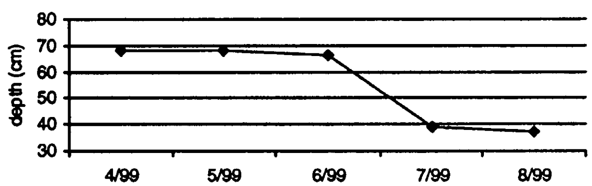


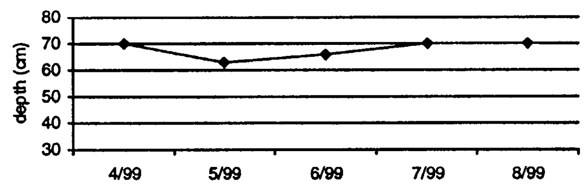
PP - Treatment 6



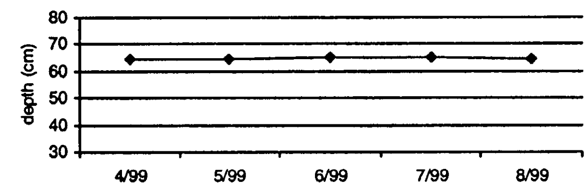
PP - Treatment 7



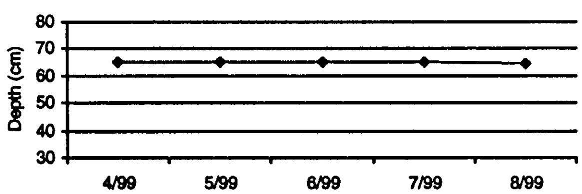
PP - Treatment 8



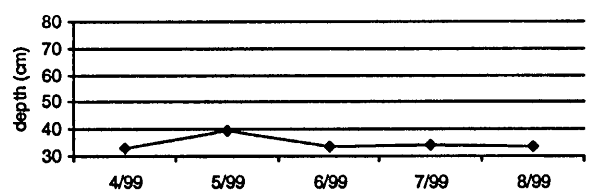
PP - Treatment 9



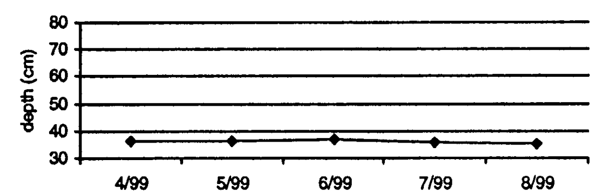
PP - Treatment 10



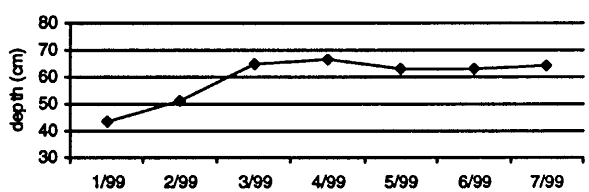
PP - Treatment 11



PP - Treatment 12



STC - Treatment 1



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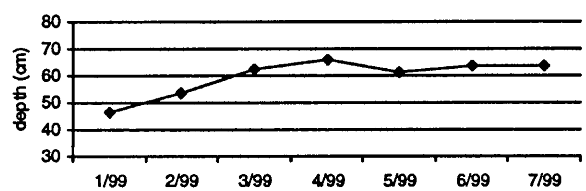
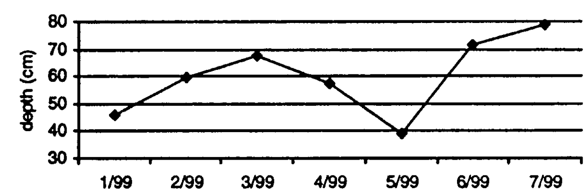


STC - Treatment 3



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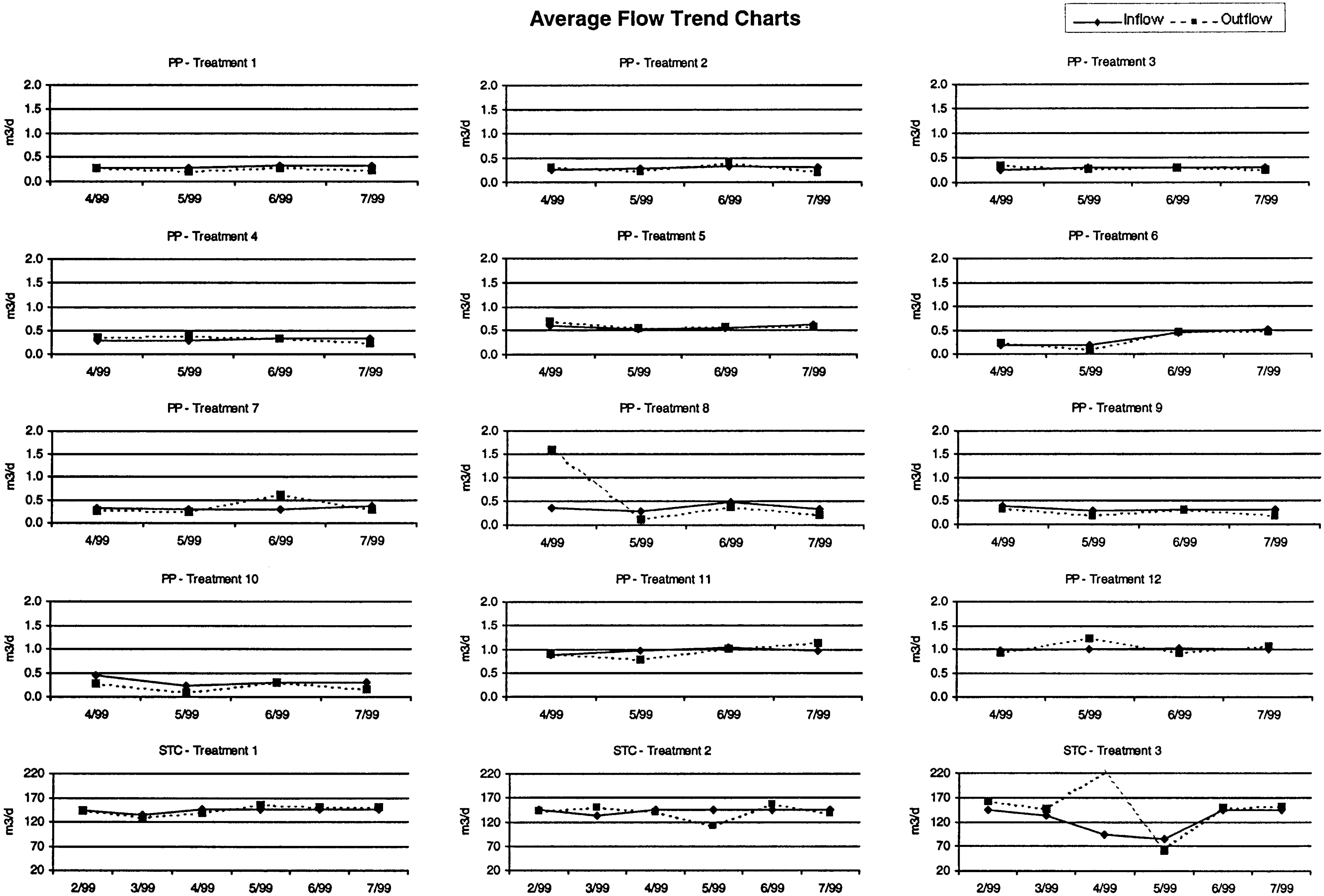
SFWMD PSTA Research Project Data Summary
Average Flow Trend Charts



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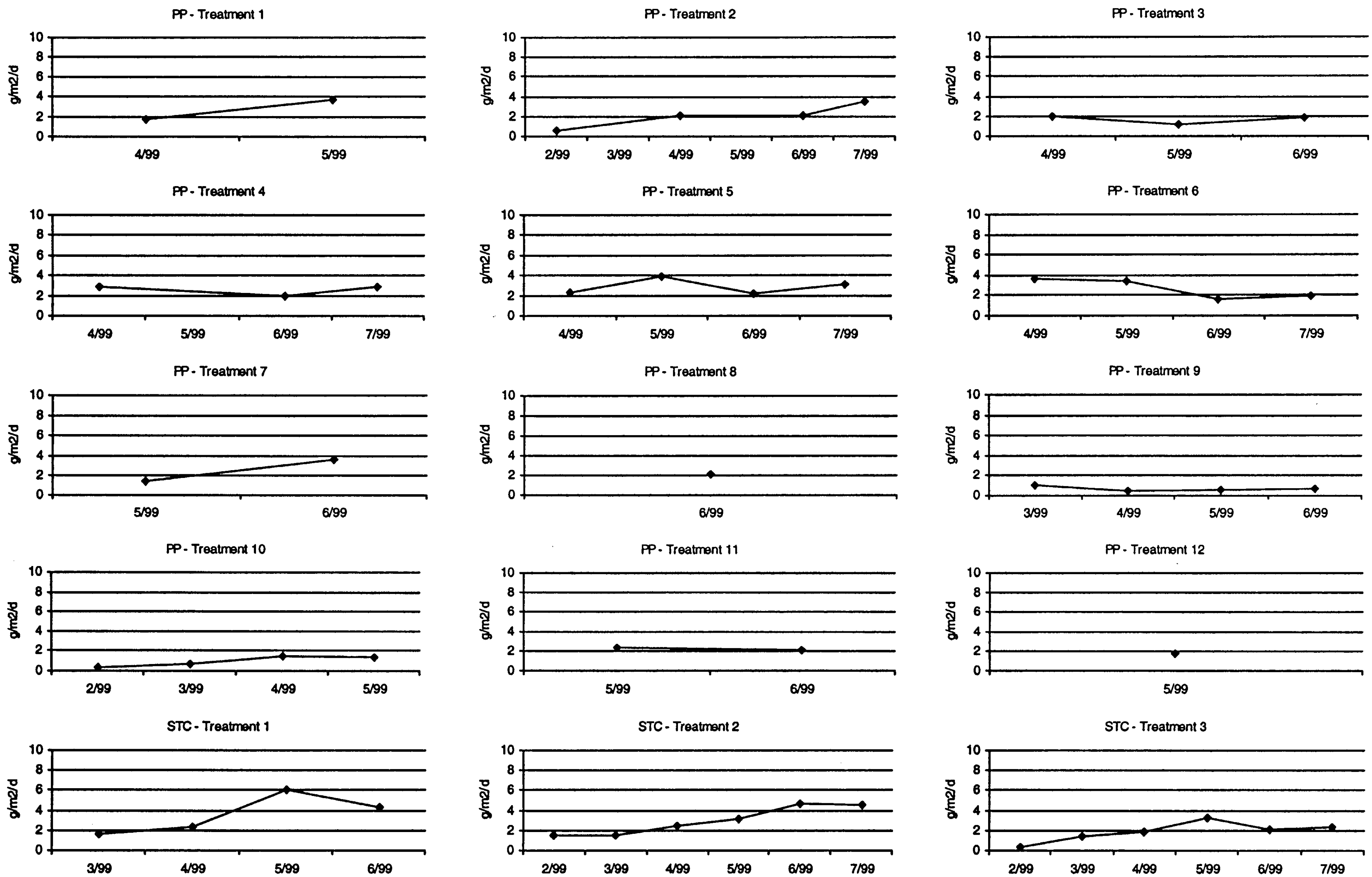
Average GPP Trend Charts



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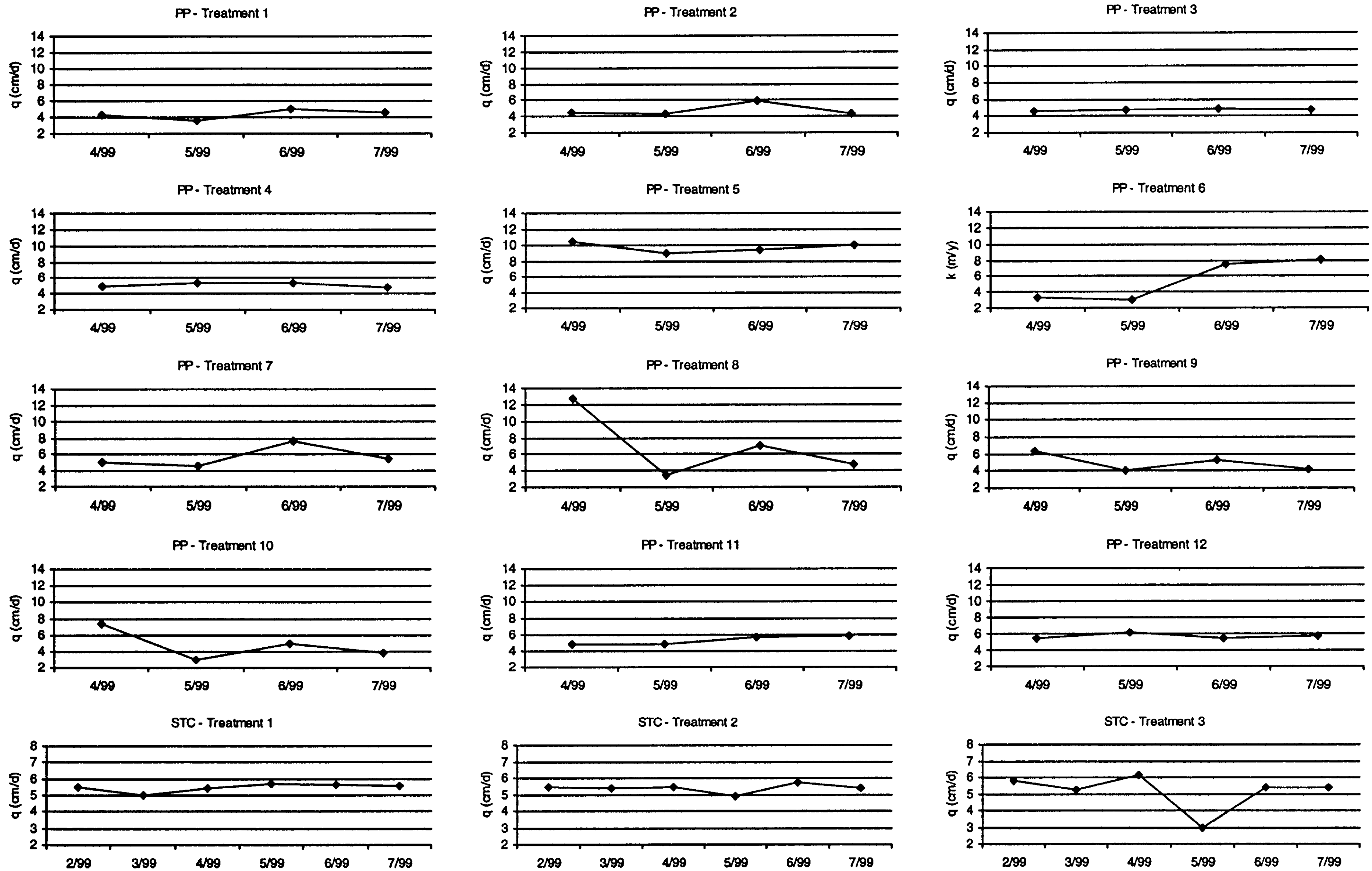
Average Hydraulic Loading Rate Trend Charts



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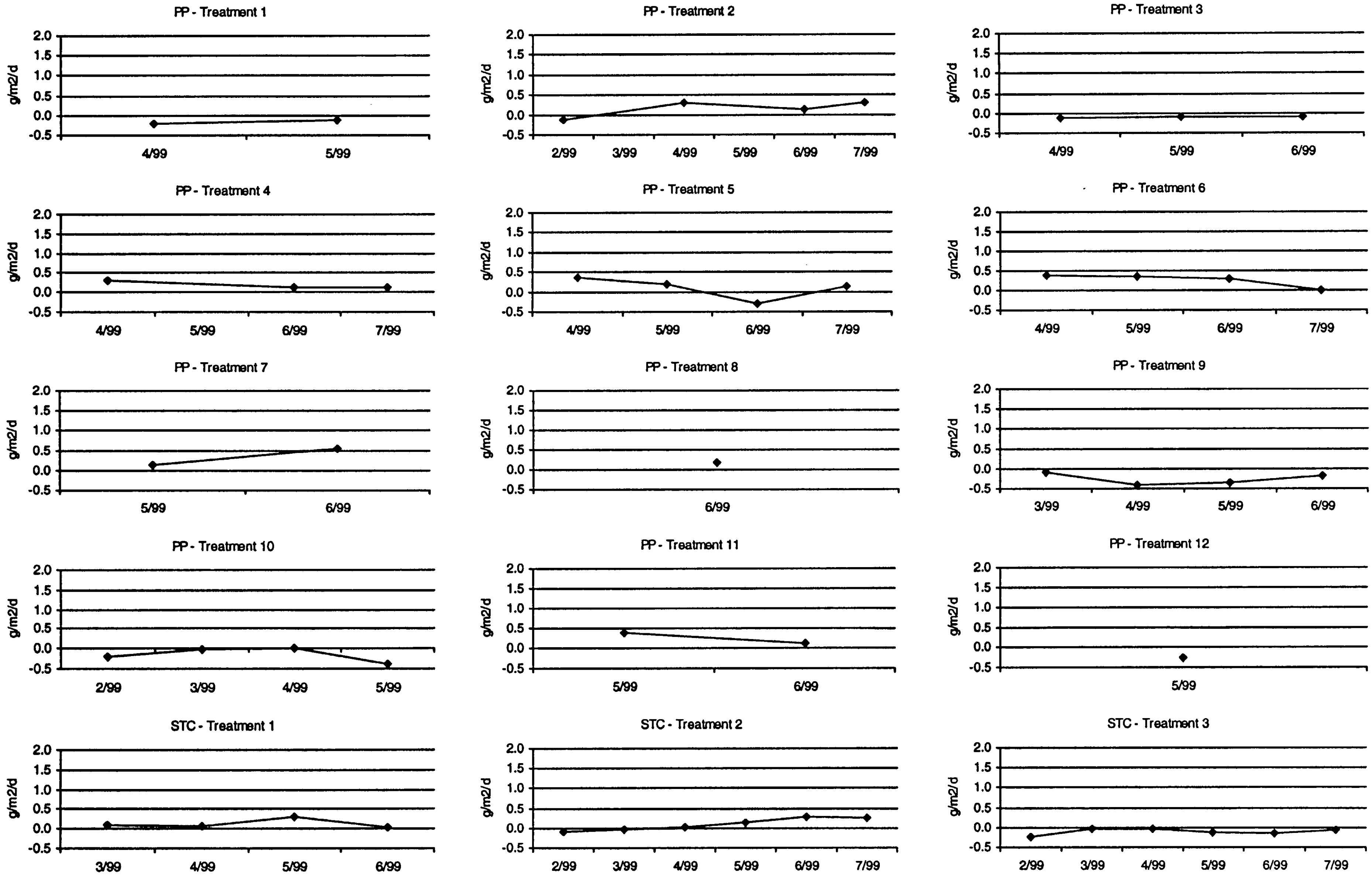
SFWMD PSTA Research Project Data Summary
Average NPP(24hr) Trend Charts



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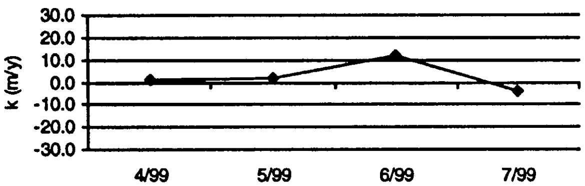
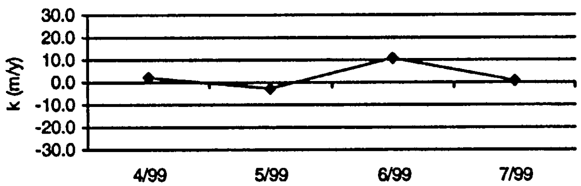
SFWMD PSTA Research Project Data Summary
Average Phosphorus Settling Rate Trend Charts

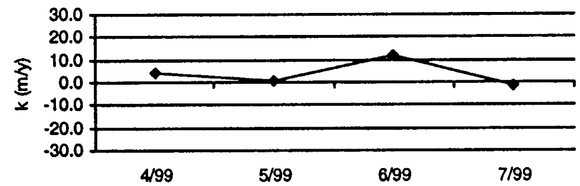
PP - Treatment 1



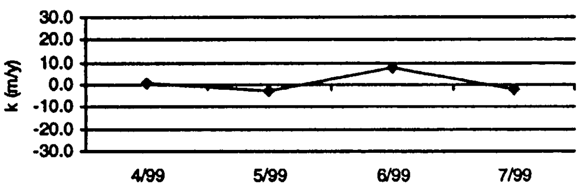
PP - Treatment 2



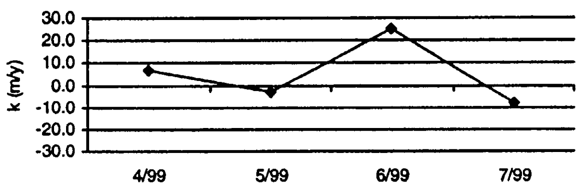
PP - Treatment 3



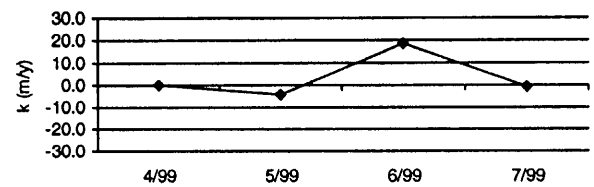
PP - Treatment 4



PP - Treatment 5



PP - Treatment 6



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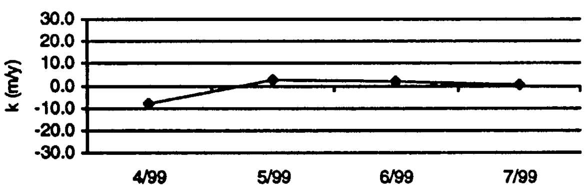

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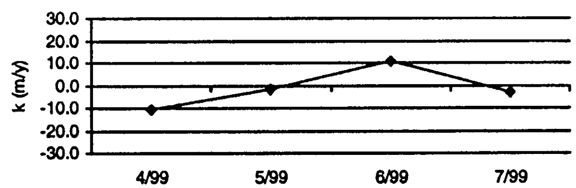
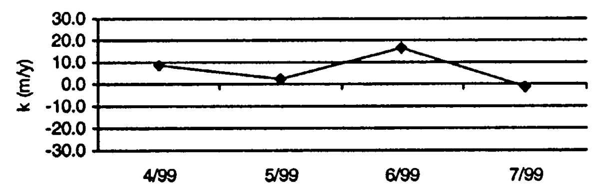
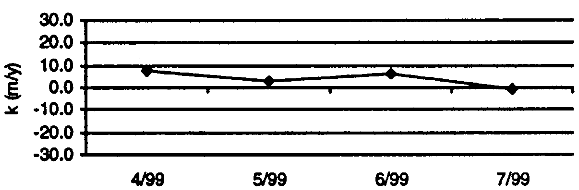


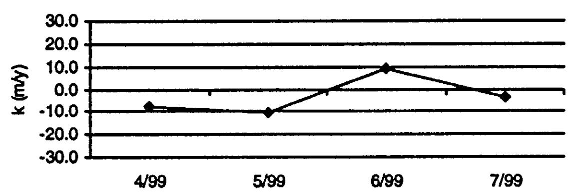
PP - Treatment 9



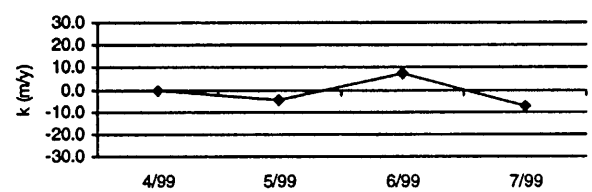
PP - Treatment 10



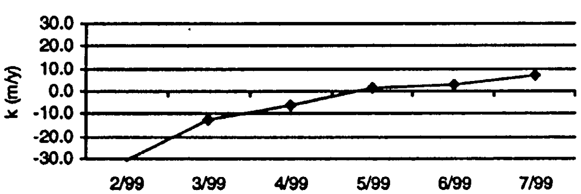
PP - Treatment 11



PP - Treatment 12



STC - Treatment 1



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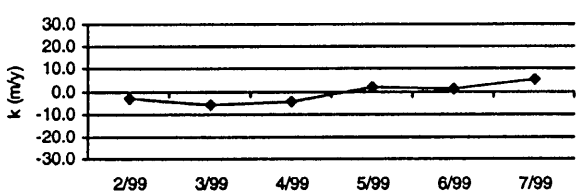

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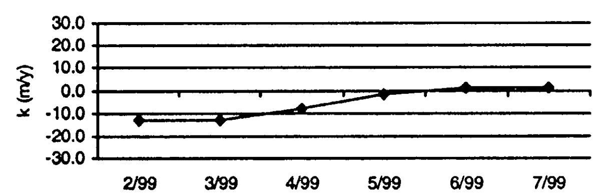

SFWMD PSTA Research Project Data Summary
Average Periphyton Biomass Trend Charts

—◆— Dry Wt - - -■- - - Ash-Free Dry Wt

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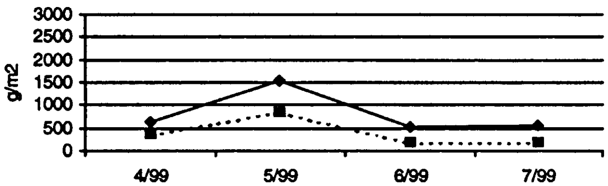

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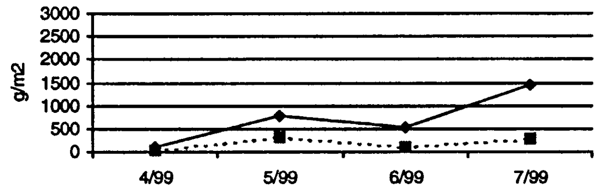

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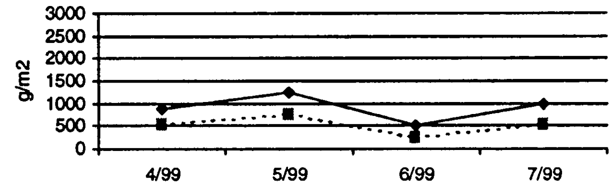

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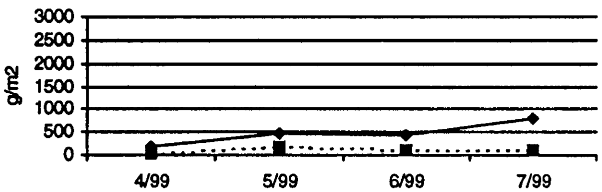
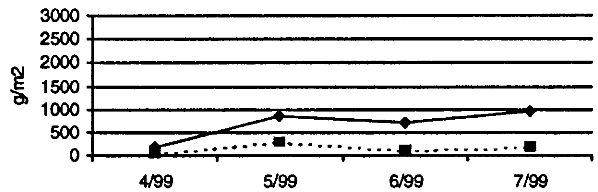
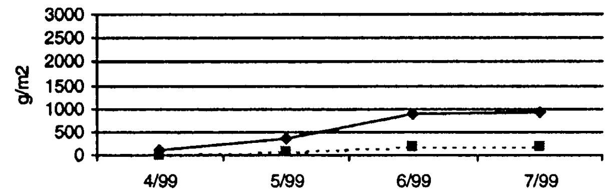


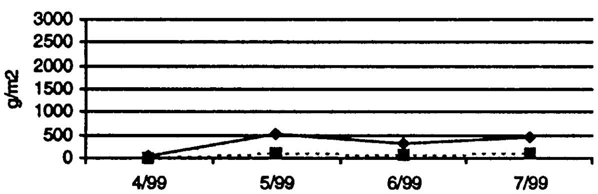
PP - Treatment 5



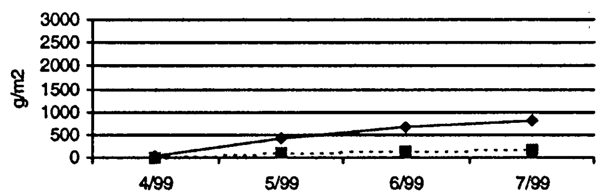
PP - Treatment 6



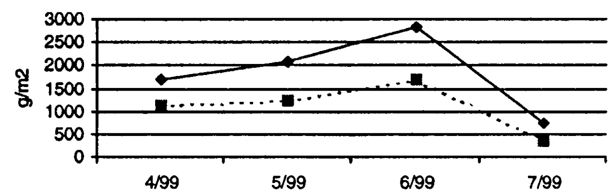
PP - Treatment 7



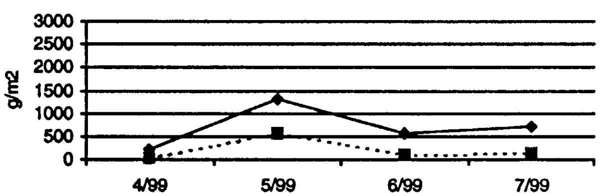
PP - Treatment 8



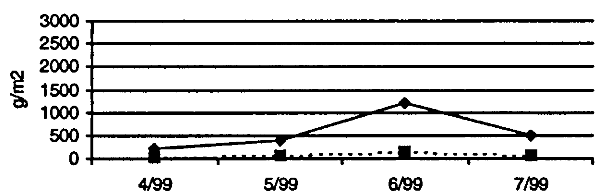
PP - Treatment 9



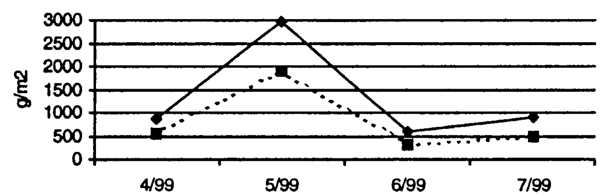
PP - Treatment 10



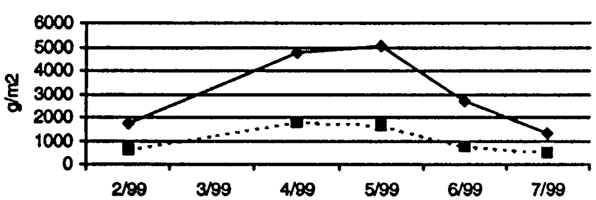
PP - Treatment 11



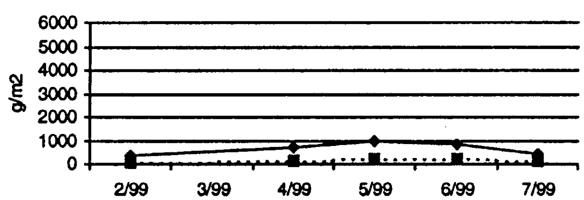
PP - Treatment 12



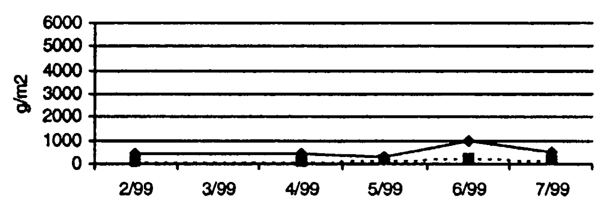
STC - Treatment 1



STC - Treatment 2

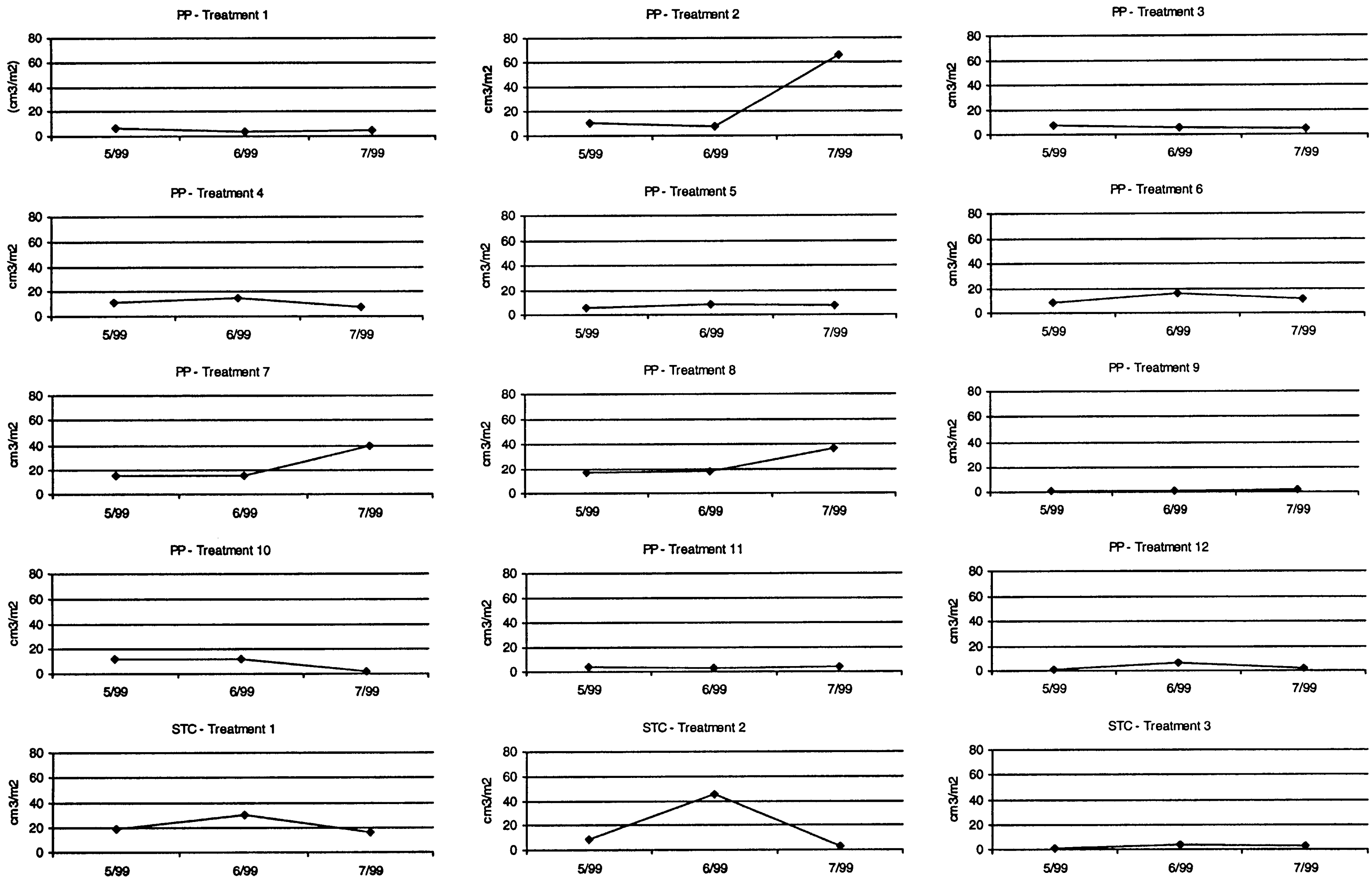


STC - Treatment 3



9/3/99 03:02 PM

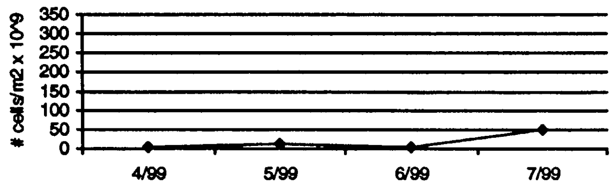
SFWMD PSTA Research Project Data Summary
Average Periphyton Biovolume Charts



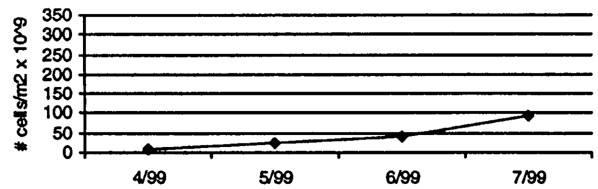
9/3/99 04:58 PM

SFWMD PSTA Research Project Data Summary
Average Periphyton Cell Density Charts

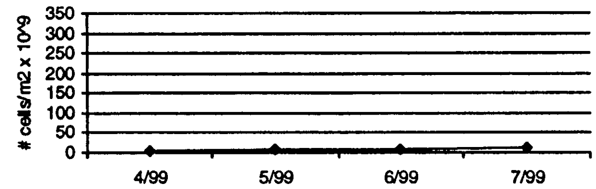
PP - Treatment 1



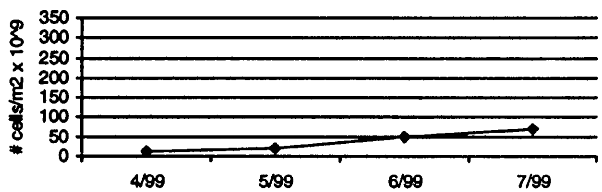
PP - Treatment 2



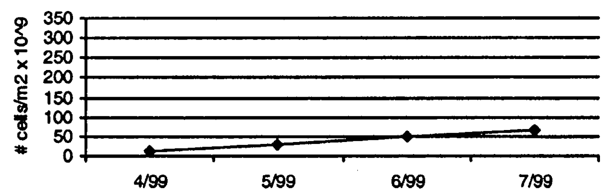
PP - Treatment 3



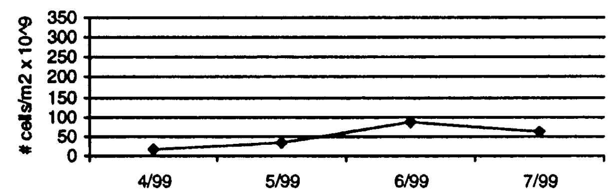
PP - Treatment 4



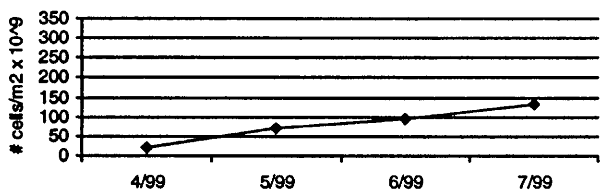
PP - Treatment 5



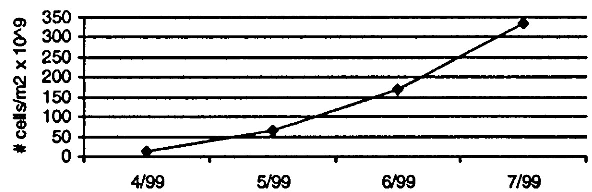
PP - Treatment 6



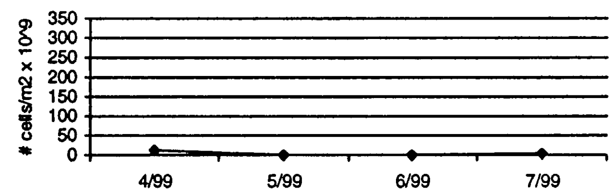
PP - Treatment 7



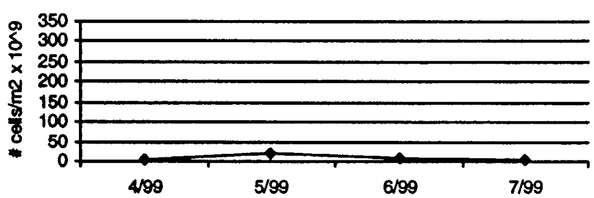
PP - Treatment 8



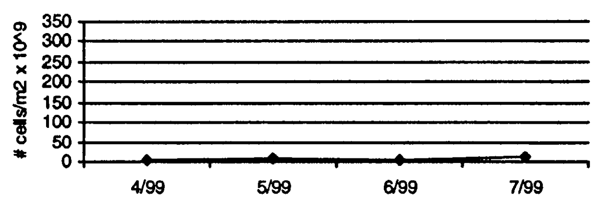
PP - Treatment 9



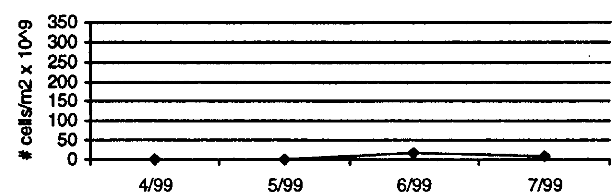
PP - Treatment 10



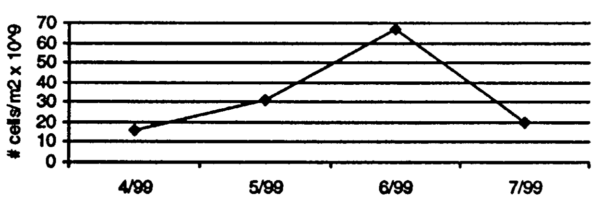
PP - Treatment 11



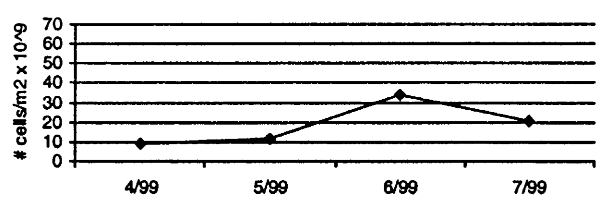
PP - Treatment 12



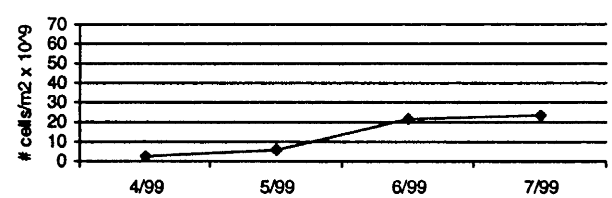
STC - Treatment 1



STC - Treatment 2



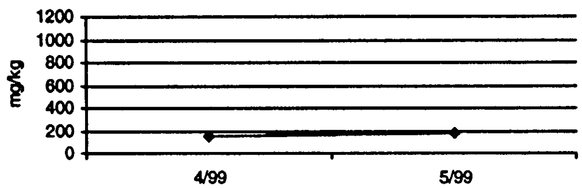
STC - Treatment 3



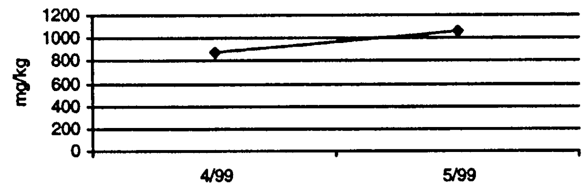
9/3/99 04:48 PM

SFWMD PSTA Research Project Data Summary
Average Sediment Total Phosphorus Trend Charts

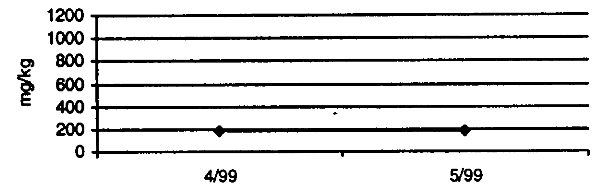
PP - Treatment 1



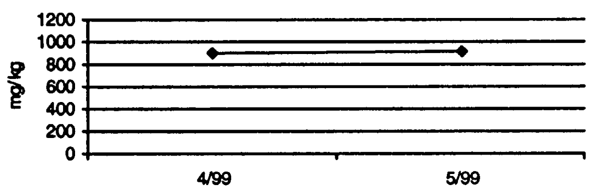
PP - Treatment 2



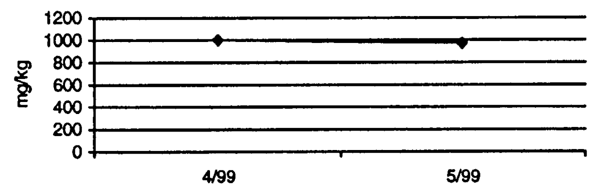
PP - Treatment 3



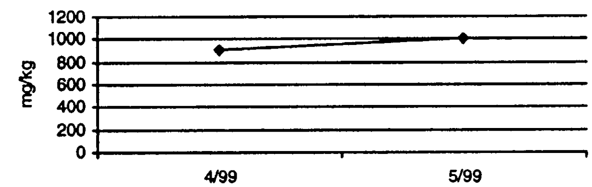
PP - Treatment 4



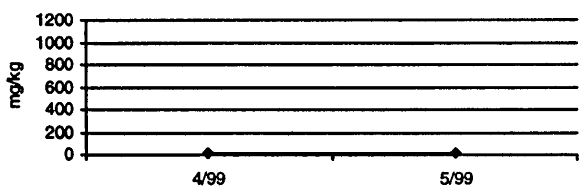
PP - Treatment 5



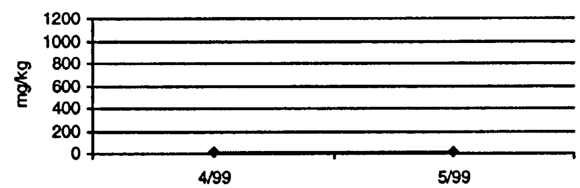
PP - Treatment 6



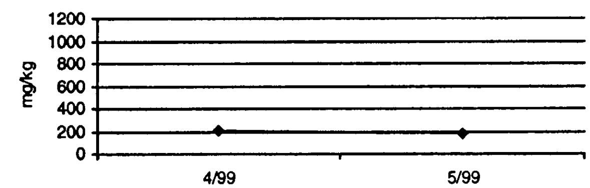
PP - Treatment 7



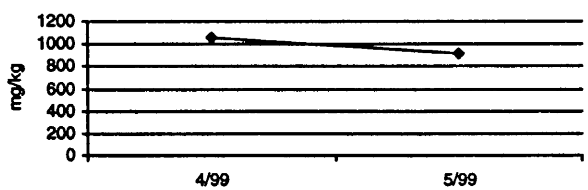
PP - Treatment 8



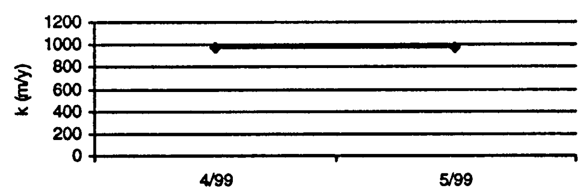
PP - Treatment 9



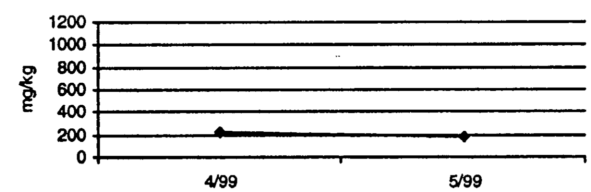
PP - Treatment 10



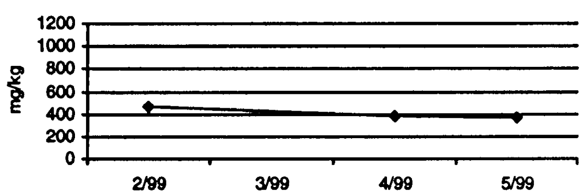
PP - Treatment 11



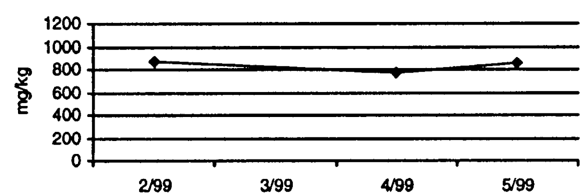
PP - Treatment 12



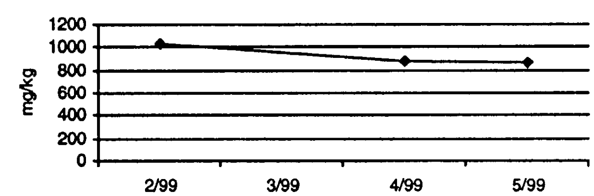
STC - Treatment 1



STC - Treatment 2

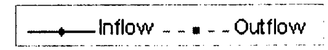


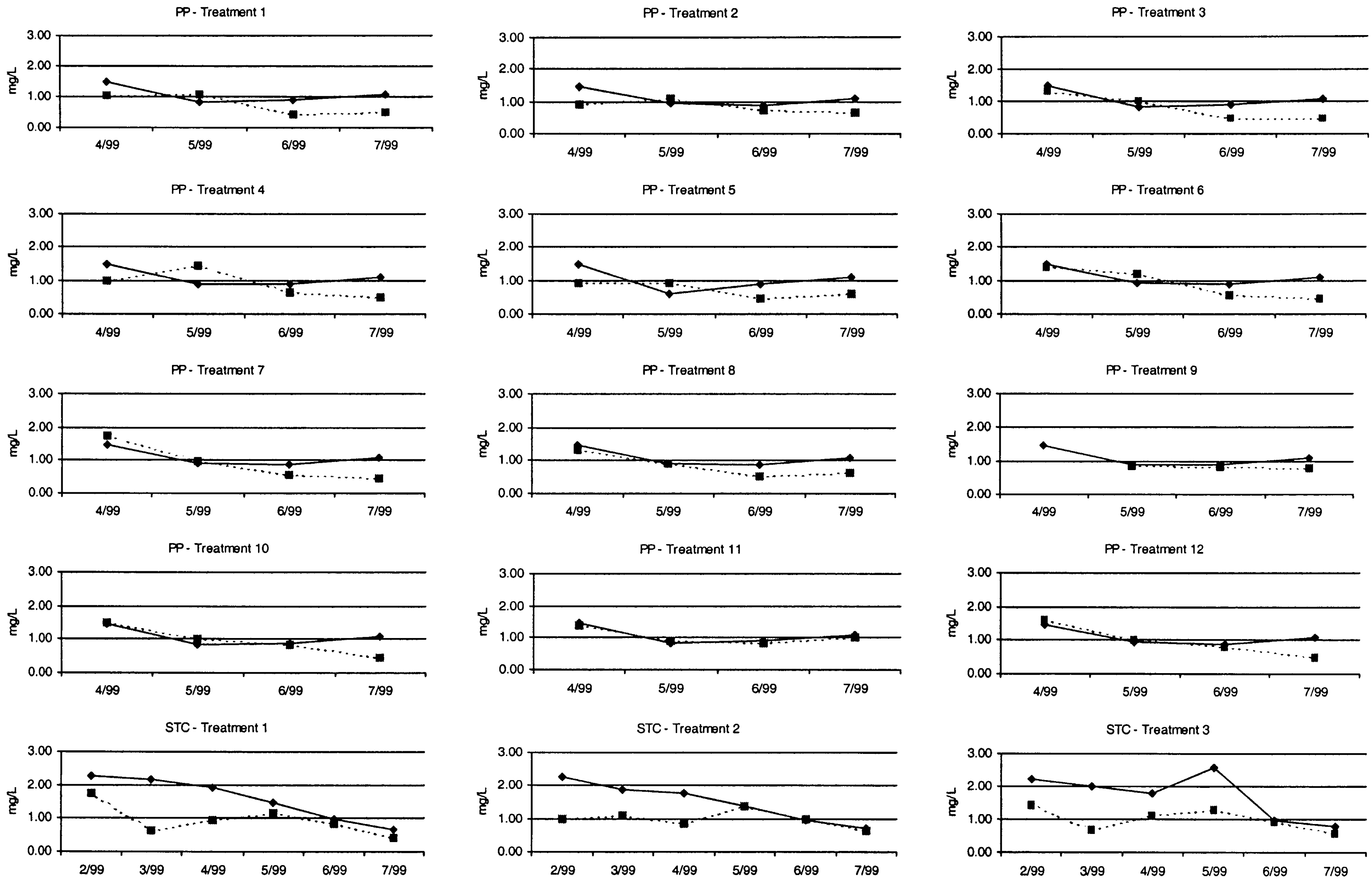
STC - Treatment 3



9/7/99 08:56 AM

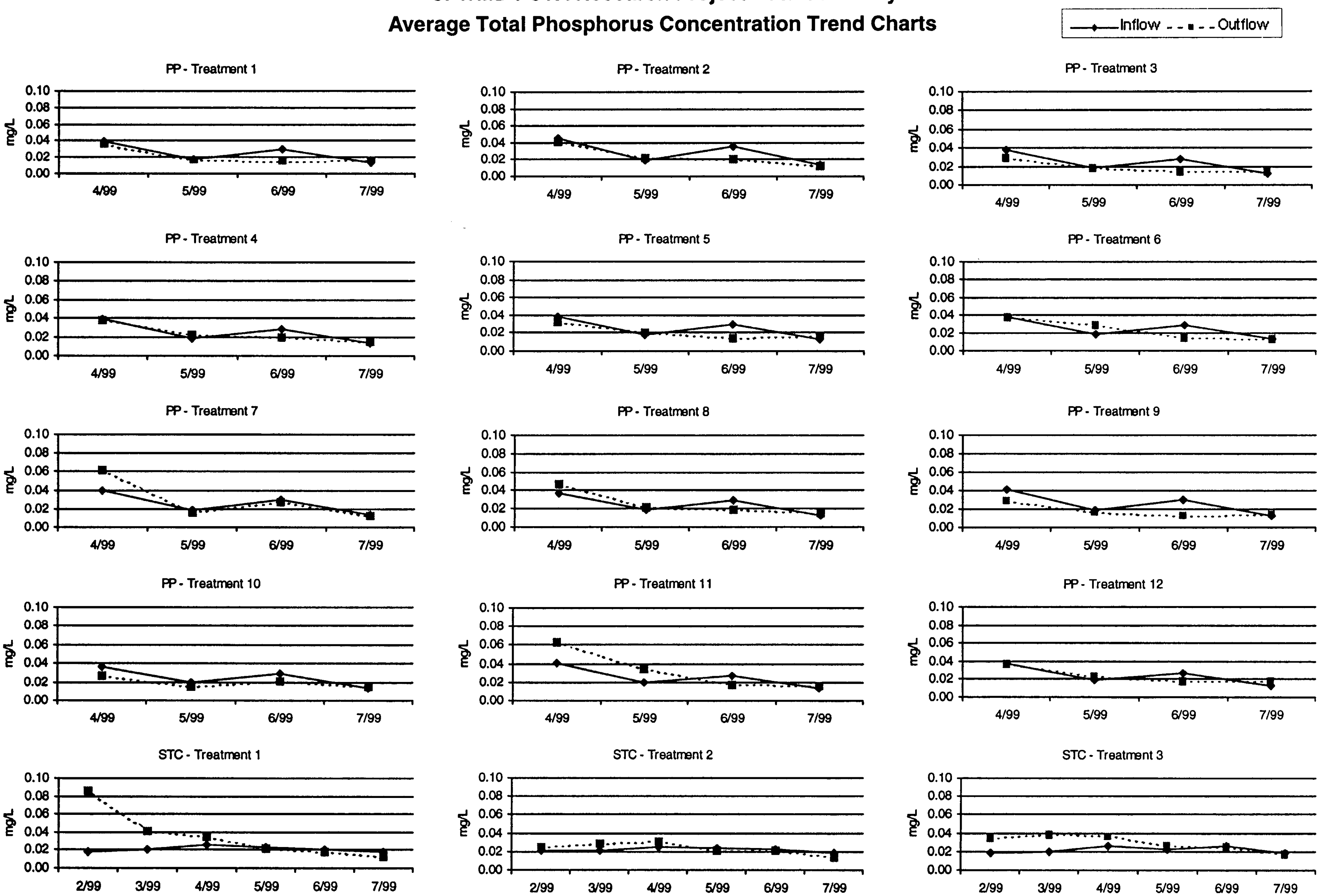
SFWMD PSTA Research Project Data Summary
Average Total Nitrogen Concentration Trend Charts





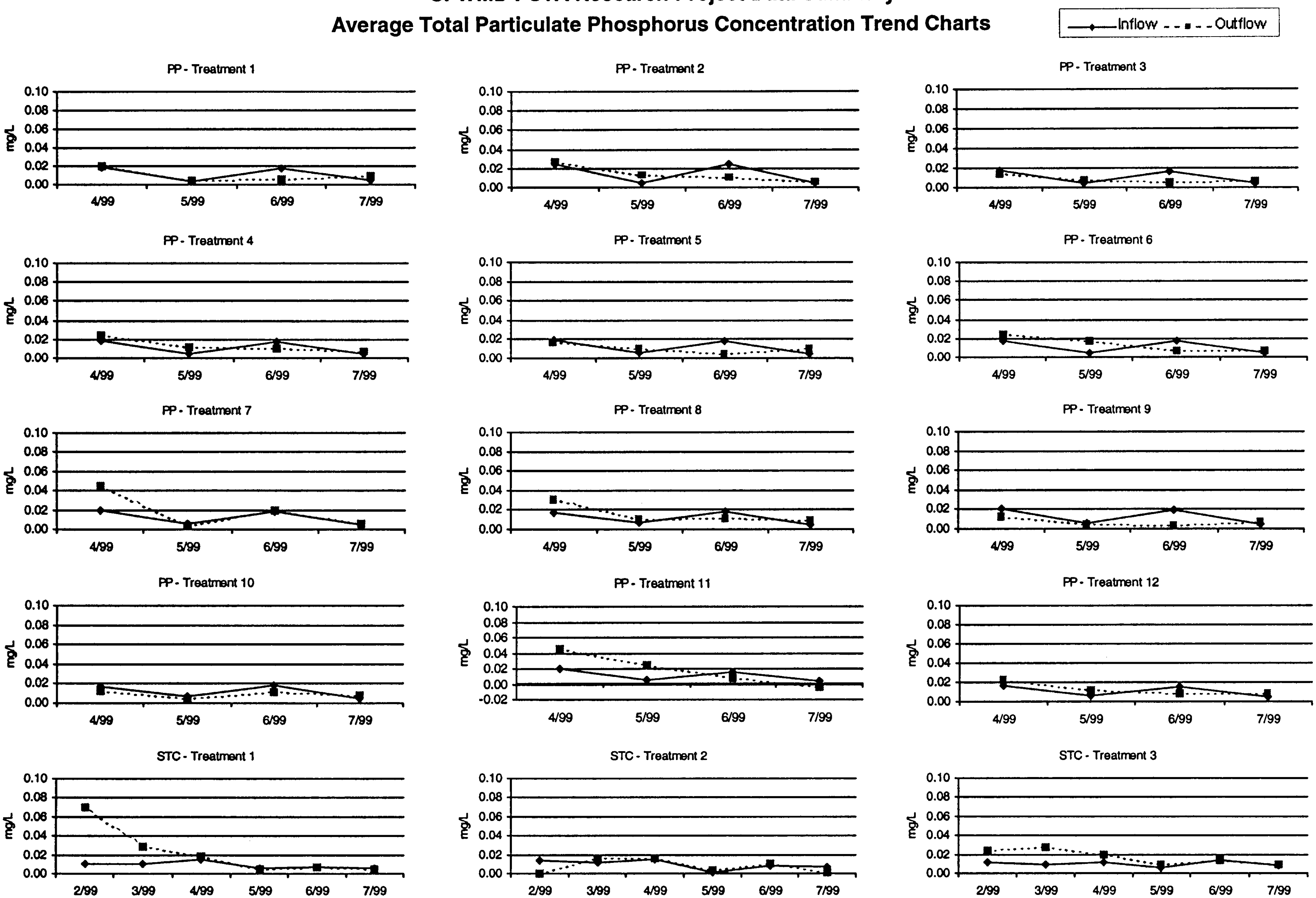
10/8/99 04:36 PM

SFWMD PSTA Research Project Data Summary
Average Total Phosphorus Concentration Trend Charts



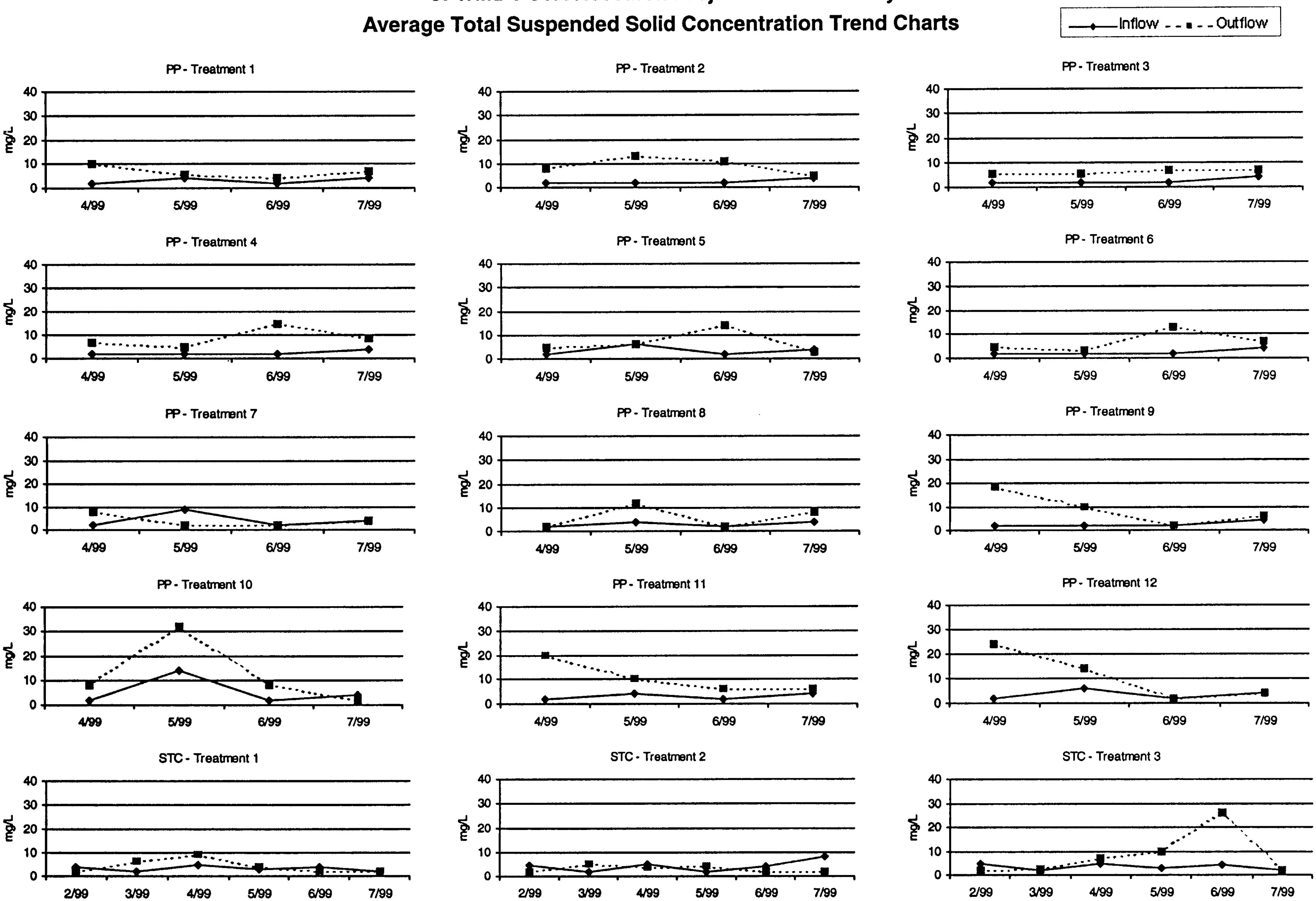
8/31/99 09:29 AM

SFWMD PSTA Research Project Data Summary
Average Total Particulate Phosphorus Concentration Trend Charts



9/7/99 08:57 AM

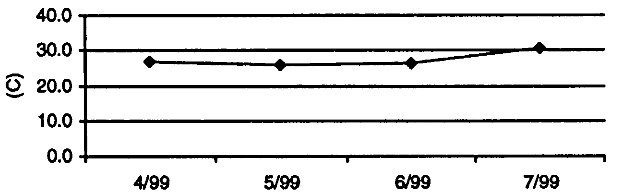
SFWMD PSTA Research Project Data Summary
Average Total Suspended Solid Concentration Trend Charts



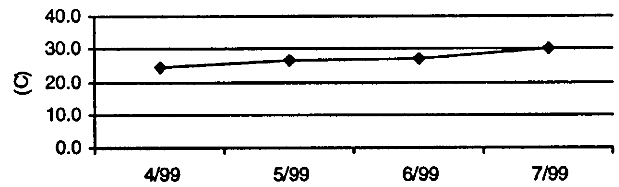
9/7/99 04:41 PM

SFWMD PSTA Research Project Data Summary
Average Water Temperature Trend Charts

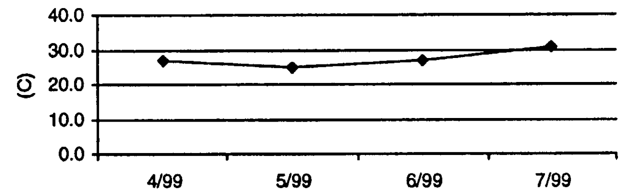
PP - Treatment 1



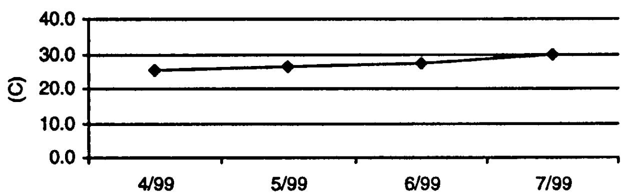
PP - Treatment 2



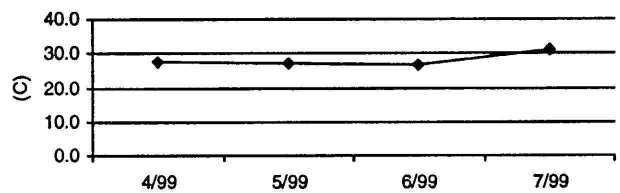
PP - Treatment 3



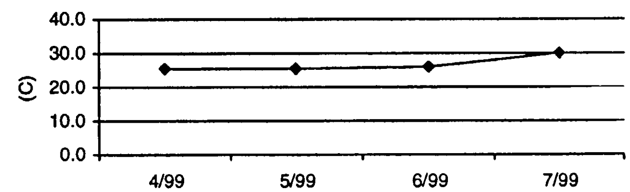
PP - Treatment 4



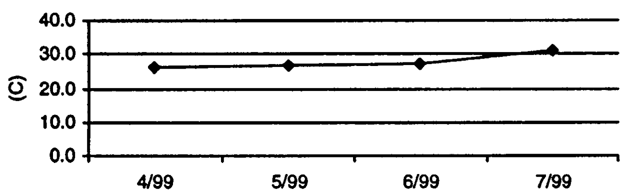
PP - Treatment 5



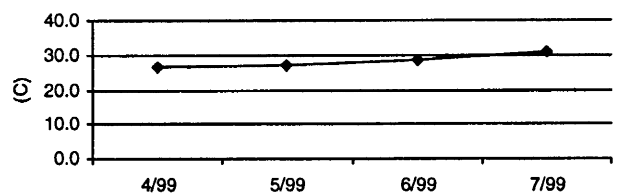
PP - Treatment 6



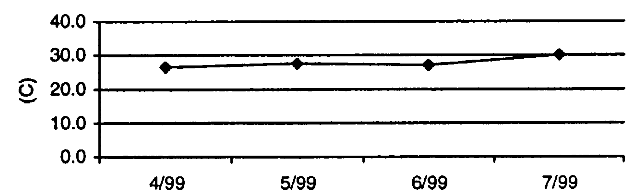
PP - Treatment 7



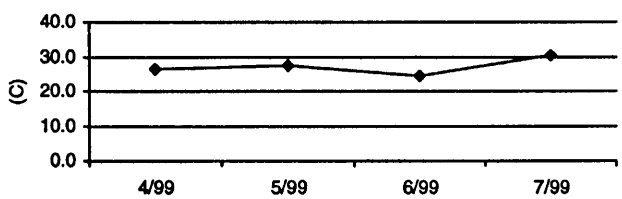
PP - Treatment 8



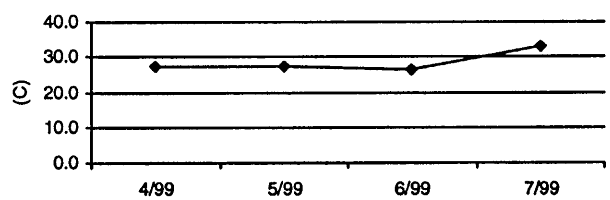
PP - Treatment 9



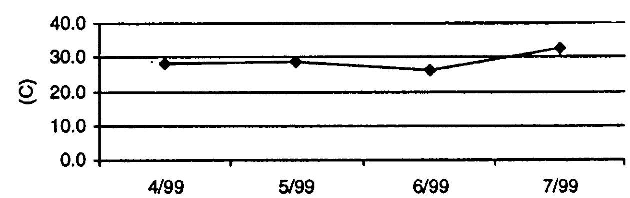
PP - Treatment 10



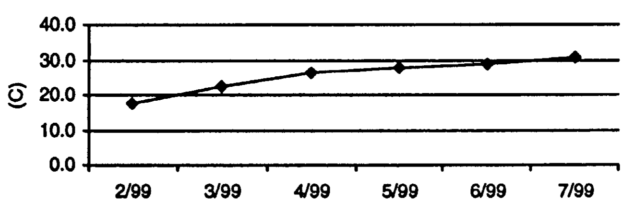
PP - Treatment 11



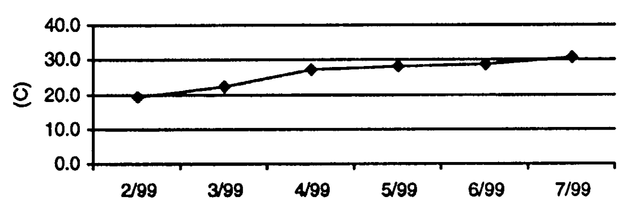
PP - Treatment 12



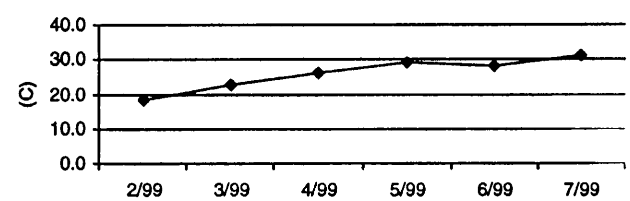
STC - Treatment 1



STC - Treatment 2

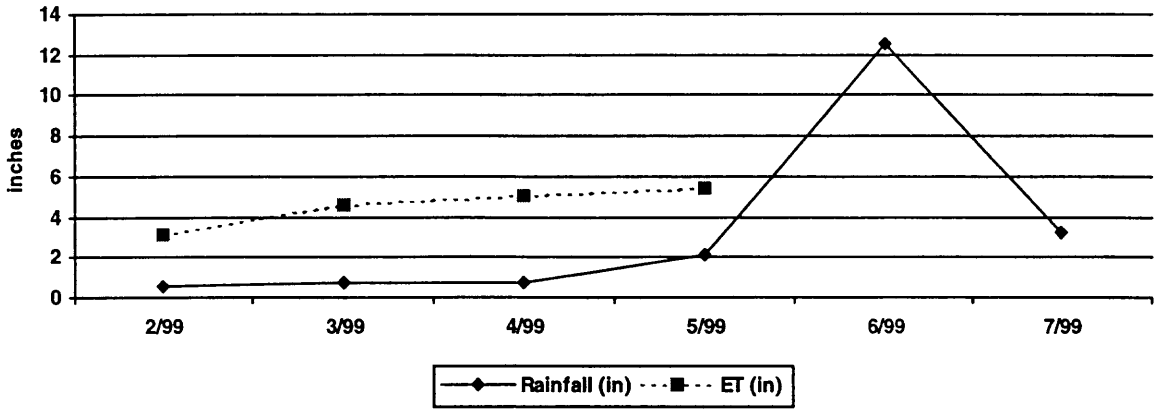


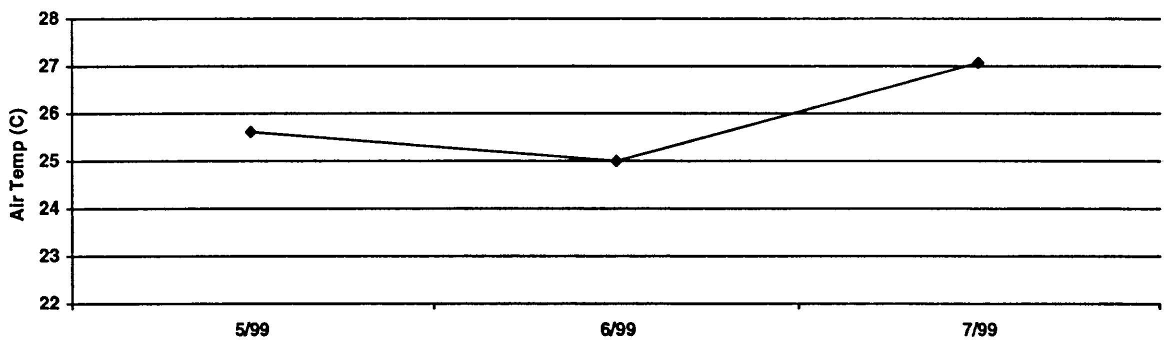
STC - Treatment 3

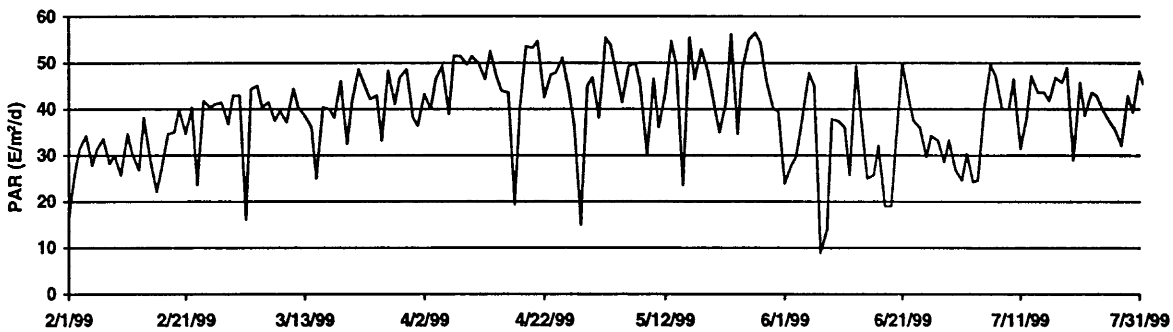


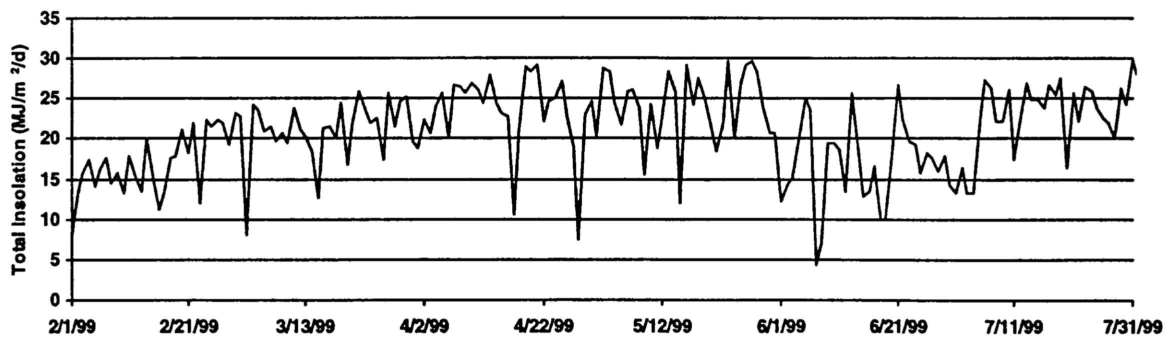
9/10/99 04:17 PM

SFWMD PSTA Research Project Data Summary
Environmental Summary

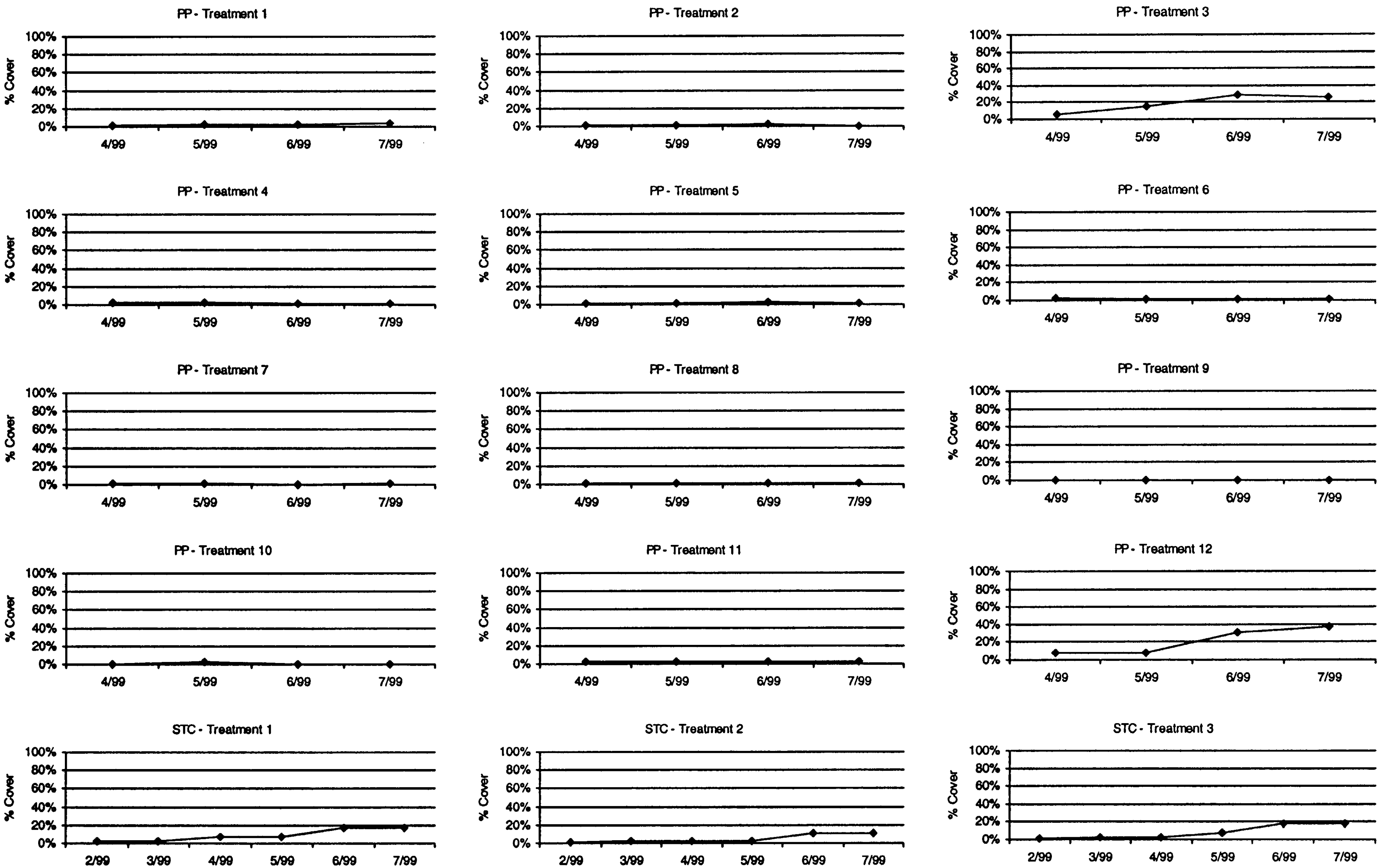








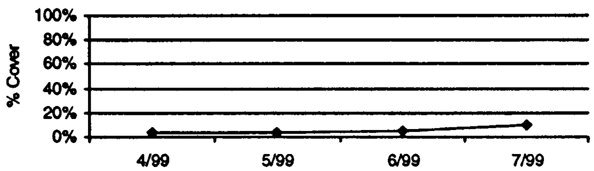
SFWMD PSTA Research Project Data Summary
Estimated Emergent Plant Percent Cover Trend Charts



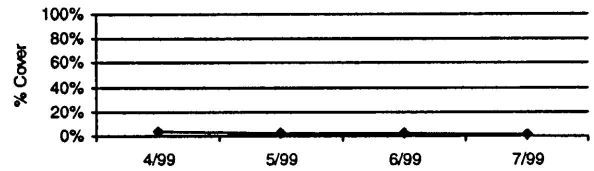
9/7/99 09:05 AM

SFWMD PSTA Research Project Data Summary
Estimated Macrophyte Percent Cover Trend Charts

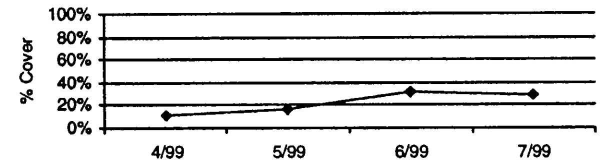
PP - Treatment 1



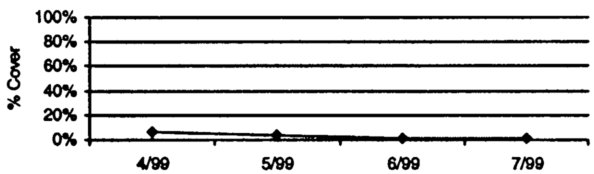
PP - Treatment 2



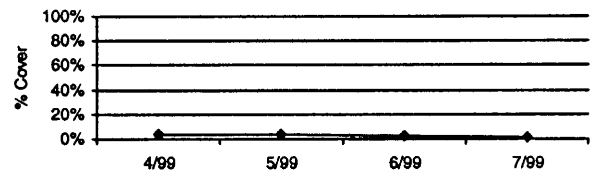
PP - Treatment 3



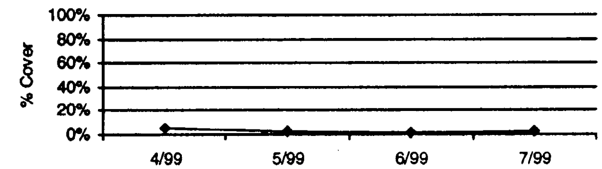
PP - Treatment 4



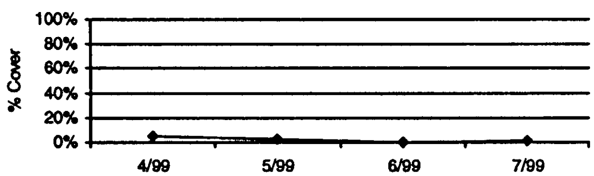
PP - Treatment 5



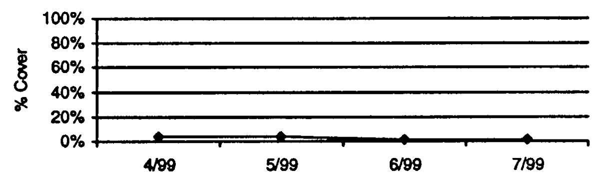
PP - Treatment 6



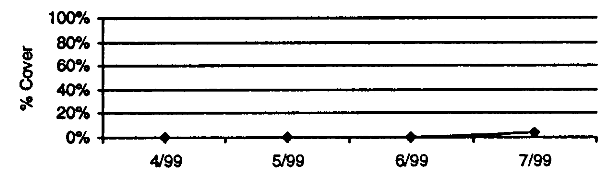
PP - Treatment 7



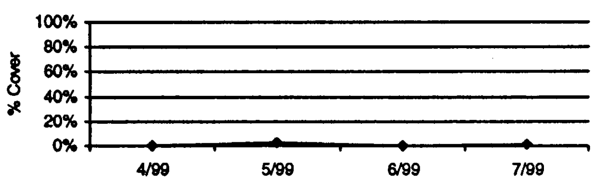
PP - Treatment 8



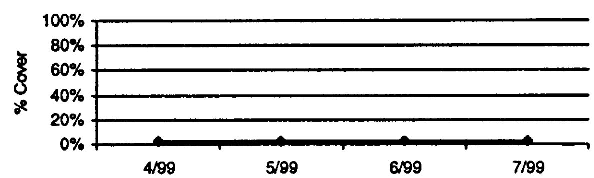
PP - Treatment 9



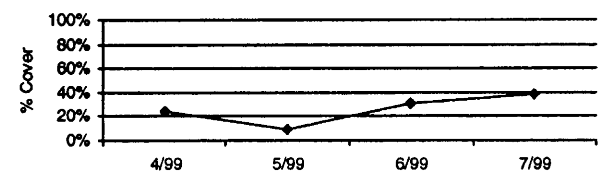
PP - Treatment 10



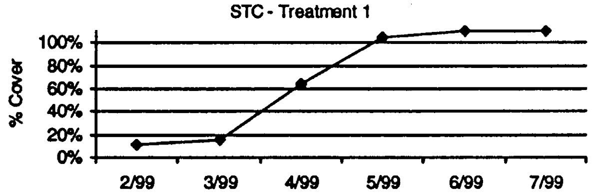
PP - Treatment 11



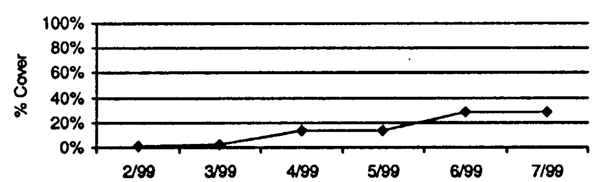
PP - Treatment 12



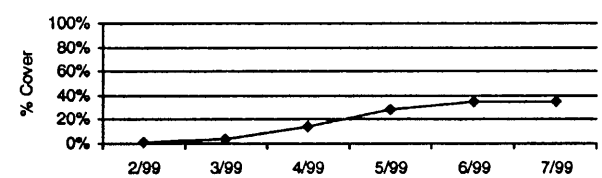
STC - Treatment 1



STC - Treatment 2



STC - Treatment 3



APPENDIX B

Porta-PSTA Tracer Test Data

REC_NO	SITE	CELL	STATION	DATE	TIME	D/T Formula	Date/Time	FLOW (mL/min)
175	PORTA	7	Inflow	04/12/1999	14:48	04/12/99 14:48	04/12/1999 14:48	400
176	PORTA	7	Inflow	04/12/1999	14:49	04/12/99 14:49	04/12/1999 14:49	250
177	PORTA	7	Inflow	04/12/1999	14:50	04/12/99 14:50	04/12/1999 14:50	250
251	PORTA	7	Inflow	04/14/1999	10:20	04/14/99 10:20	04/14/1999 10:20	500
252	PORTA	7	Inflow	04/14/1999	10:22	04/14/99 10:22	04/14/1999 10:22	370
253	PORTA	7	Inflow	04/14/1999	10:24	04/14/99 10:24	04/14/1999 10:24	250
323	PORTA	7	Inflow	04/19/1999	11:04	04/19/99 11:04	04/19/1999 11:04	250
324	PORTA	7	Inflow	04/19/1999	11:05	04/19/99 11:05	04/19/1999 11:05	250
325	PORTA	7	Inflow	04/19/1999	11:07	04/19/99 11:07	04/19/1999 11:07	250
399	PORTA	7	Inflow	04/19/1999	15:20	04/19/99 15:20	04/19/1999 15:20	255
9	PORTA	7	Inflow	04/21/1999	11:10	04/21/99 11:10	04/21/1999 11:10	30
10	PORTA	7	Inflow	04/21/1999	11:11	04/21/99 11:11	04/21/1999 11:11	260
28	PORTA	7	Inflow	04/21/1999	11:39	04/21/99 11:39	04/21/1999 11:39	250
507	PORTA	7	Inflow	04/21/1999	11:39	04/21/99 11:39	04/21/1999 11:39	250
539	PORTA	7	Inflow	04/22/1999	11:04	04/22/99 11:04	04/22/1999 11:04	0
560	PORTA	7	Inflow	04/22/1999	11:07	04/22/99 11:07	04/22/1999 11:07	250
580	PORTA	7	Inflow	04/23/1999	11:46	04/23/99 11:46	04/23/1999 11:46	180
598	PORTA	7	Inflow	04/23/1999	11:50	04/23/99 11:50	04/23/1999 11:50	260
57	PORTA	7	Inflow	04/26/1999	9:56	04/26/99 09:56	04/26/1999 9:56	290
58	PORTA	7	Inflow	04/26/1999	9:57	04/26/99 09:57	04/26/1999 9:57	220
59	PORTA	7	Inflow	04/26/1999	9:58	04/26/99 09:58	04/26/1999 9:58	220
109	PORTA	7	Inflow	04/26/1999	10:48	04/26/99 10:48	04/26/1999 10:48	280
110	PORTA	7	Inflow	04/26/1999	10:49	04/26/99 10:49	04/26/1999 10:49	280
606	PORTA	7	Inflow	04/30/1999	11:32	04/30/99 11:32	04/30/1999 11:32	110
628	PORTA	7	Inflow	04/30/1999	11:35	04/30/99 11:35	04/30/1999 11:35	240
654	PORTA	7	Inflow	05/04/1999	12:33	05/04/99 12:33	05/04/1999 12:33	0
655	PORTA	7	Inflow	05/04/1999	12:35	05/04/99 12:35	05/04/1999 12:35	260
700	PORTA	7	Inflow	05/05/1999	12:06	05/05/99 12:06	05/05/1999 12:06	0
701	PORTA	7	Inflow	05/05/1999	12:09	05/05/99 12:09	05/05/1999 12:09	280
728	PORTA	7	Inflow	05/06/1999	9:00	05/06/99 09:00	05/06/1999 9:00	255
758	PORTA	7	Inflow	05/07/1999	9:43	05/07/99 09:43	05/07/1999 9:43	100
759	PORTA	7	Inflow	05/07/1999	9:44	05/07/99 09:44	05/07/1999 9:44	280
819	PORTA	7	Inflow	05/11/1999	12:28	05/11/99 12:28	05/11/1999 12:28	250
860	PORTA	7	Inflow	05/12/1999	9:52	05/12/99 09:52	05/12/1999 9:52	90
884	PORTA	7	Inflow	05/12/1999	9:57	05/12/99 09:57	05/12/1999 9:57	240
906	PORTA	7	Inflow	05/12/1999	17:12	05/12/99 17:12	05/12/1999 17:12	85
926	PORTA	7	Inflow	05/13/1999	10:05	05/13/99 10:05	05/13/1999 10:05	40
942	PORTA	7	Inflow	05/13/1999	10:06	05/13/99 10:06	05/13/1999 10:06	230
965	PORTA	7	Inflow	05/17/1999	9:05:00 AM	05/17/99 09:05	05/17/1999 9:05	0
966	PORTA	7	Inflow	05/17/1999	9:06:00 AM	05/17/99 09:06	05/17/1999 9:06	265
1015	PORTA	7	Inflow	05/18/1999	3:21:00 PM	05/18/99 15:21	05/18/1999 15:21	420
1016	PORTA	7	Inflow	05/18/1999	3:22:00 PM	05/18/99 15:22	05/18/1999 15:22	190
1017	PORTA	7	Inflow	05/18/1999	3:23:00 PM	05/18/99 15:23	05/18/1999 15:23	230
1079	PORTA	7	Inflow	05/19/1999	8:55:00 AM	05/19/99 08:55	05/19/1999 8:55	95
1080	PORTA	7	Inflow	05/19/1999	8:56:00 AM	05/19/99 08:56	05/19/1999 8:56	385
1081	PORTA	7	Inflow	05/19/1999	8:57:00 AM	05/19/99 08:57	05/19/1999 8:57	210
1111	PORTA	7	Inflow	05/20/1999	8:57:00 AM	05/20/99 08:57	05/20/1999 8:57	55
1112	PORTA	7	Inflow	05/20/1999	8:58:00 AM	05/20/99 08:58	05/20/1999 8:58	320
1113	PORTA	7	Inflow	05/20/1999	8:59:00 AM	05/20/99 08:59	05/20/1999 8:59	260
1162	PORTA	7	Inflow	05/24/1999	10:22:00 AM	05/24/99 10:22	05/24/1999 10:22	0
1163	PORTA	7	Inflow	05/24/1999	10:23:00 AM	05/24/99 10:23	05/24/1999 10:23	300
1164	PORTA	7	Inflow	05/24/1999	10:24:00 AM	05/24/99 10:24	05/24/1999 10:24	275
1278	PORTA	7	Inflow	05/25/1999	8:34:00 AM	05/25/99 08:34	05/25/1999 8:34	50
1279	PORTA	7	Inflow	05/25/1999	8:35:00 AM	05/25/99 08:35	05/25/1999 8:35	275
1280	PORTA	7	Inflow	05/25/1999	8:36:00 AM	05/25/99 08:36	05/25/1999 8:36	275
1362	PORTA	7	Inflow	06/01/1999	10:46:00 AM	06/01/99 10:46	06/01/1999 10:46	395
1363	PORTA	7	Inflow	06/01/1999	10:47:00 AM	06/01/99 10:47	06/01/1999 10:47	250
1364	PORTA	7	Inflow	06/01/1999	10:48:00 AM	06/01/99 10:48	06/01/1999 10:48	250
1442	PORTA	7	Inflow	06/03/1999	11:46:00 AM	06/03/99 11:46	06/03/1999 11:46	70
1443	PORTA	7	Inflow	06/03/1999	11:47:00 AM	06/03/99 11:47	06/03/1999 11:47	280
1444	PORTA	7	Inflow	06/03/1999	11:48:00 AM	06/03/99 11:48	06/03/1999 11:48	275
1531	PORTA	7	Inflow	06/07/1999	10:16:00 AM	06/07/99 10:16	06/07/1999 10:16	40
1532	PORTA	7	Inflow	06/07/1999	10:17:00 AM	06/07/99 10:17	06/07/1999 10:17	245
1533	PORTA	7	Inflow	06/07/1999	10:18:00 AM	06/07/99 10:18	06/07/1999 10:18	250
1603	PORTA	7	Inflow	06/09/1999	9:55:00 AM	06/09/99 09:55	06/09/1999 9:55	0
1604	PORTA	7	Inflow	06/09/1999	9:57:00 AM	06/09/99 09:57	06/09/1999 9:57	255

REC_NO	SITE	CELL	STATION	DATE	TIME	D/T Formula	Date/Time	FLOW (mL/min)
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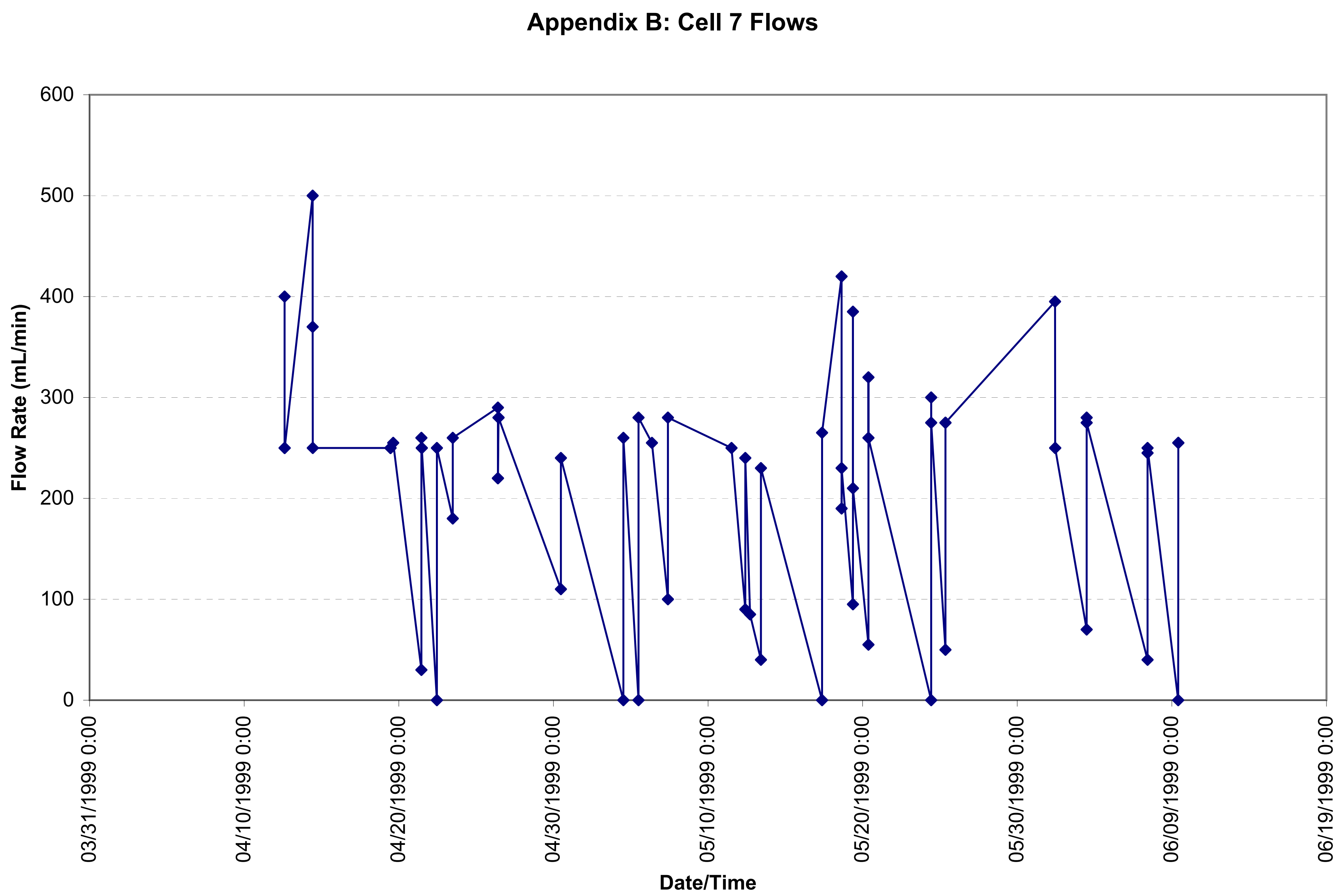
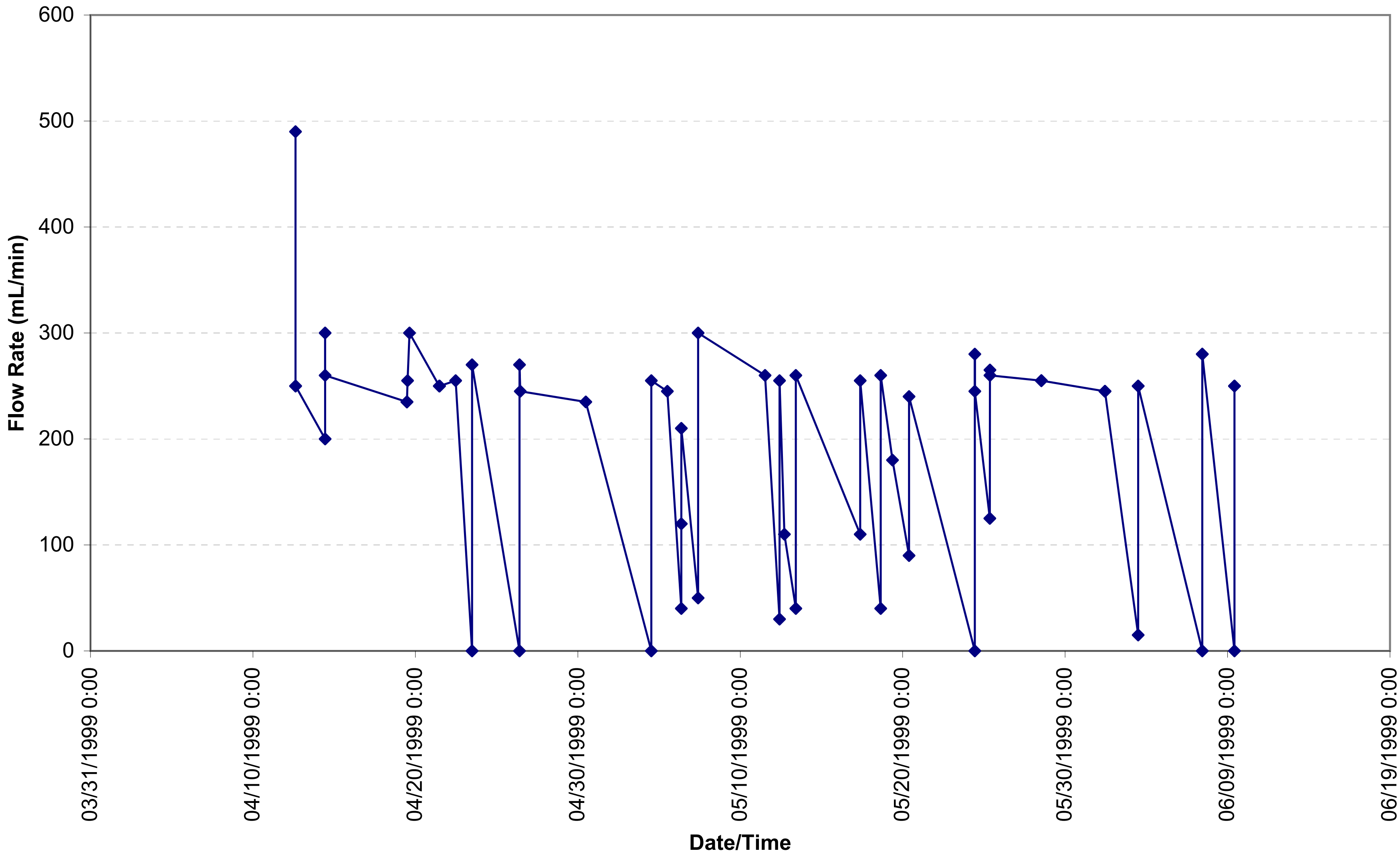
184	PORTA	10	Inflow	04/12/1999	14:58	04/12/99 14:58	04/12/1999 14:58	490
185	PORTA	10	Inflow	04/12/1999	15:00	04/12/99 15:00	04/12/1999 15:00	250
186	PORTA	10	Inflow	04/12/1999	15:02	04/12/99 15:02	04/12/1999 15:02	250
260	PORTA	10	Inflow	04/14/1999	10:42	04/14/99 10:42	04/14/1999 10:42	200
261	PORTA	10	Inflow	04/14/1999	10:44	04/14/99 10:44	04/14/1999 10:44	300
262	PORTA	10	Inflow	04/14/1999	10:46	04/14/99 10:46	04/14/1999 10:46	260
332	PORTA	10	Inflow	04/19/1999	11:27	04/19/99 11:27	04/19/1999 11:27	235
333	PORTA	10	Inflow	04/19/1999	11:29	04/19/99 11:29	04/19/1999 11:29	235
334	PORTA	10	Inflow	04/19/1999	11:31	04/19/99 11:31	04/19/1999 11:31	235
381	PORTA	10	Inflow	04/19/1999	12:27	04/19/99 12:27	04/19/1999 12:27	255
402	PORTA	10	Inflow	04/19/1999	15:23	04/19/99 15:23	04/19/1999 15:23	300
11	PORTA	10	Inflow	04/21/1999	11:15	04/21/99 11:15	04/21/1999 11:15	250
24	PORTA	10	Inflow	04/21/1999	11:43	04/21/99 11:43	04/21/1999 11:43	250
504	PORTA	10	Inflow	04/21/1999	11:43	04/21/99 11:43	04/21/1999 11:43	250
536	PORTA	10	Inflow	04/22/1999	11:35	04/22/99 11:35	04/22/1999 11:35	255
577	PORTA	10	Inflow	04/23/1999	11:43	04/23/99 11:43	04/23/1999 11:43	0
596	PORTA	10	Inflow	04/23/1999	11:45	04/23/99 11:45	04/23/1999 11:45	270
84	PORTA	10	Inflow	04/26/1999	9:56	04/26/99 09:56	04/26/1999 9:56	0
85	PORTA	10	Inflow	04/26/1999	9:58	04/26/99 09:58	04/26/1999 9:58	270
105	PORTA	10	Inflow	04/26/1999	11:04	04/26/99 11:04	04/26/1999 11:04	245
609	PORTA	10	Inflow	04/30/1999	11:45	04/30/99 11:45	04/30/1999 11:45	235
661	PORTA	10	Inflow	05/04/1999	12:38	05/04/99 12:38	05/04/1999 12:38	0
662	PORTA	10	Inflow	05/04/1999	12:40	05/04/99 12:40	05/04/1999 12:40	255
705	PORTA	10	Inflow	05/05/1999	12:14	05/05/99 12:14	05/05/1999 12:14	245
726	PORTA	10	Inflow	05/06/1999	8:57	05/06/99 08:57	05/06/1999 8:57	40
727	PORTA	10	Inflow	05/06/1999	8:59	05/06/99 08:59	05/06/1999 8:59	120
729	PORTA	10	Inflow	05/06/1999	9:01	05/06/99 09:01	05/06/1999 9:01	210
763	PORTA	10	Inflow	05/07/1999	9:49	05/07/99 09:49	05/07/1999 9:49	50
764	PORTA	10	Inflow	05/07/1999	9:50	05/07/99 09:50	05/07/1999 9:50	300
822	PORTA	10	Inflow	05/11/1999	12:34	05/11/99 12:34	05/11/1999 12:34	260
863	PORTA	10	Inflow	05/12/1999	10:05	05/12/99 10:05	05/12/1999 10:05	30
887	PORTA	10	Inflow	05/12/1999	10:06	05/12/99 10:06	05/12/1999 10:06	255
909	PORTA	10	Inflow	05/12/1999	17:18	05/12/99 17:18	05/12/1999 17:18	110
928	PORTA	10	Inflow	05/13/1999	10:12	05/13/99 10:12	05/13/1999 10:12	40
944	PORTA	10	Inflow	05/13/1999	10:13	05/13/99 10:13	05/13/1999 10:13	260
971	PORTA	10	Inflow	05/17/1999	9:12:00 AM	05/17/99 09:12	05/17/1999 9:12	110
972	PORTA	10	Inflow	05/17/1999	9:13:00 AM	05/17/99 09:13	05/17/1999 9:13	255
1021	PORTA	10	Inflow	05/18/1999	3:31:00 PM	05/18/99 15:31	05/18/1999 15:31	40
1022	PORTA	10	Inflow	05/18/1999	3:32:00 PM	05/18/99 15:32	05/18/1999 15:32	260
1086	PORTA	10	Inflow	05/19/1999	9:01:00 AM	05/19/99 09:01	05/19/1999 9:01	180
1118	PORTA	10	Inflow	05/20/1999	9:22:00 AM	05/20/99 09:22	05/20/1999 9:22	90
1119	PORTA	10	Inflow	05/20/1999	9:23:00 AM	05/20/99 09:23	05/20/1999 9:23	240
1171	PORTA	10	Inflow	05/24/1999	10:38:00 AM	05/24/99 10:38	05/24/1999 10:38	0
1172	PORTA	10	Inflow	05/24/1999	10:39:00 AM	05/24/99 10:39	05/24/1999 10:39	280
1173	PORTA	10	Inflow	05/24/1999	10:40:00 AM	05/24/99 10:40	05/24/1999 10:40	245
1287	PORTA	10	Inflow	05/25/1999	8:50:00 AM	05/25/99 08:50	05/25/1999 8:50	125
1288	PORTA	10	Inflow	05/25/1999	8:51:00 AM	05/25/99 08:51	05/25/1999 8:51	265
1289	PORTA	10	Inflow	05/25/1999	8:52:00 AM	05/25/99 08:52	05/25/1999 8:52	260
1329	PORTA	10	Inflow	05/28/1999	12:55:00 PM	05/28/99 12:55	05/28/1999 12:55	255
1330	PORTA	10	Inflow	05/28/1999	12:56:00 PM	05/28/99 12:56	05/28/1999 12:56	255
1331	PORTA	10	Inflow	05/28/1999	12:57:00 PM	05/28/99 12:57	05/28/1999 12:57	255
1371	PORTA	10	Inflow	06/01/1999	10:49:00 AM	06/01/99 10:49	06/01/1999 10:49	245
1372	PORTA	10	Inflow	06/01/1999	10:50:00 AM	06/01/99 10:50	06/01/1999 10:50	245
1373	PORTA	10	Inflow	06/01/1999	10:51:00 AM	06/01/99 10:51	06/01/1999 10:51	245
1451	PORTA	10	Inflow	06/03/1999	11:58:00 AM	06/03/99 11:58	06/03/1999 11:58	15
1452	PORTA	10	Inflow	06/03/1999	11:59:00 AM	06/03/99 11:59	06/03/1999 11:59	250
1453	PORTA	10	Inflow	06/03/1999	12:00:00 PM	06/03/99 12:00	06/03/1999 12:00	250
1540	PORTA	10	Inflow	06/07/1999	10:34:00 AM	06/07/99 10:34	06/07/1999 10:34	0
1541	PORTA	10	Inflow	06/07/1999	10:35:00 AM	06/07/99 10:35	06/07/1999 10:35	280
1542	PORTA	10	Inflow	06/07/1999	10:36:00 AM	06/07/99 10:36	06/07/1999 10:36	280
1612	PORTA	10	Inflow	06/09/1999	10:08:00 AM	06/09/99 10:08	06/09/1999 10:08	0
1613	PORTA	10	Inflow	06/09/1999	10:10:00 AM	06/09/99 10:10	06/09/1999 10:10	250
1614	PORTA	10	Inflow	06/09/1999	10:11:00 AM	06/09/99 10:11	06/09/1999 10:11	250
221	PORTA	23	Inflow	04/12/1999	16:41	04/12/99 16:41	04/12/1999 16:41	850
222	PORTA	23	Inflow	04/12/1999	16:44	04/12/99 16:44	04/12/1999 16:44	730

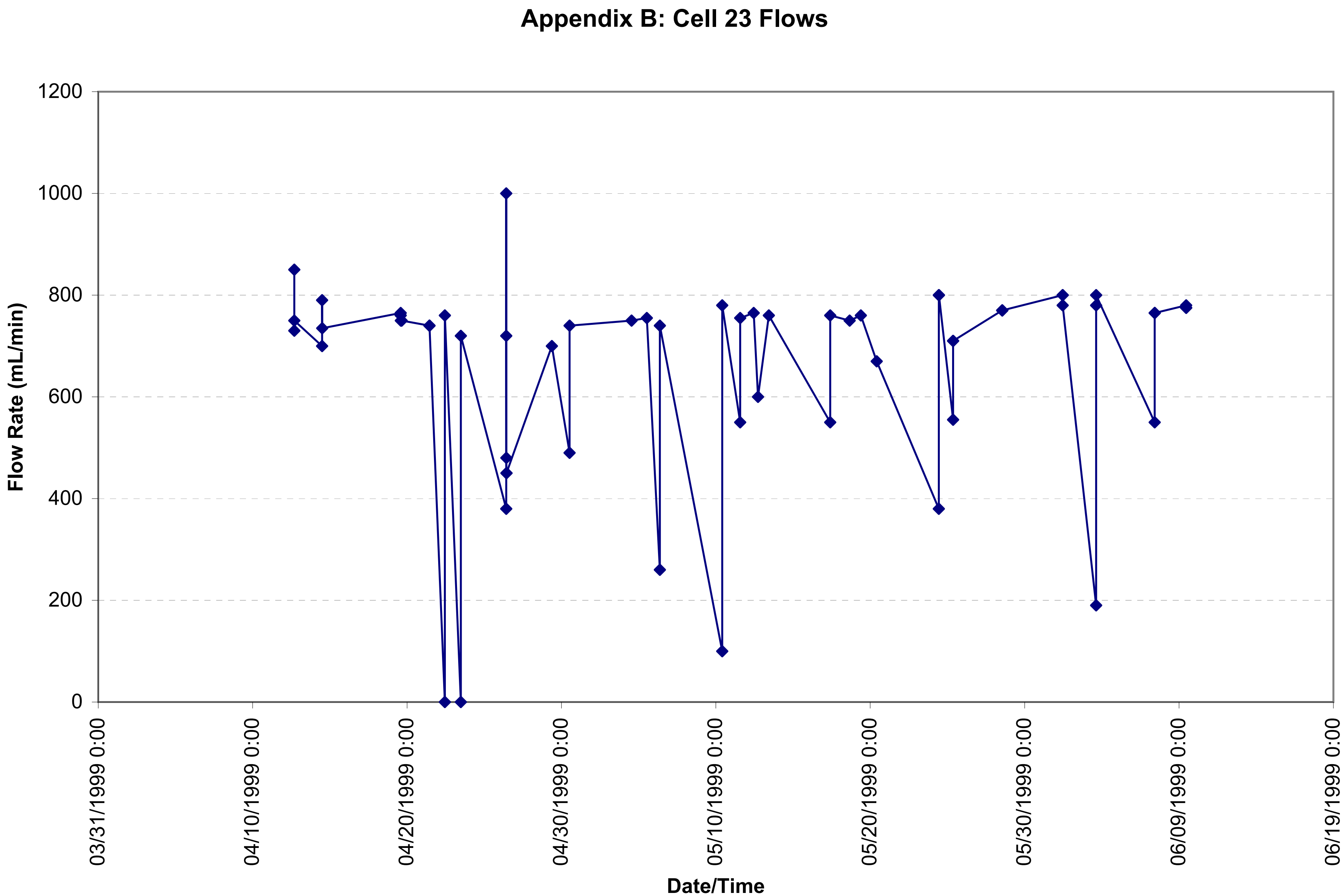
REC_NO	SITE	CELL	STATION	DATE	TIME	D/T Formula	Date/Time	FLOW (mL/min)
223	PORTA	23	Inflow	04/12/1999	16:45	04/12/99 16:45	04/12/1999 16:45	750
299	PORTA	23	Inflow	04/14/1999	12:02	04/14/99 12:02	04/14/1999 12:02	700
300	PORTA	23	Inflow	04/14/1999	12:04	04/14/99 12:04	04/14/1999 12:04	790
301	PORTA	23	Inflow	04/14/1999	12:06	04/14/99 12:06	04/14/1999 12:06	735
371	PORTA	23	Inflow	04/19/1999	14:12	04/19/99 14:12	04/19/1999 14:12	765
372	PORTA	23	Inflow	04/19/1999	14:14	04/19/99 14:14	04/19/1999 14:14	760
373	PORTA	23	Inflow	04/19/1999	14:19	04/19/99 14:19	04/19/1999 14:19	750
415	PORTA	23	Inflow	04/19/1999	15:37	04/19/99 15:37	04/19/1999 15:37	750
3	PORTA	23	Inflow	04/21/1999	10:55	04/21/99 10:55	04/21/1999 10:55	740
489	PORTA	23	Inflow	04/21/1999	10:55	04/21/99 10:55	04/21/1999 10:55	740
523	PORTA	23	Inflow	04/22/1999	10:49	04/22/99 10:49	04/22/1999 10:49	0
546	PORTA	23	Inflow	04/22/1999	10:51	04/22/99 10:51	04/22/1999 10:51	760
564	PORTA	23	Inflow	04/23/1999	11:40	04/23/99 11:40	04/23/1999 11:40	0
588	PORTA	23	Inflow	04/23/1999	11:43	04/23/99 11:43	04/23/1999 11:43	720
66	PORTA	23	Inflow	04/26/1999	10:08	04/26/99 10:08	04/26/1999 10:08	380
67	PORTA	23	Inflow	04/26/1999	10:09	04/26/99 10:09	04/26/1999 10:09	1000
68	PORTA	23	Inflow	04/26/1999	10:11	04/26/99 10:11	04/26/1999 10:11	720
119	PORTA	23	Inflow	04/26/1999	10:29	04/26/99 10:29	04/26/1999 10:29	480
120	PORTA	23	Inflow	04/26/1999	10:30	04/26/99 10:30	04/26/1999 10:30	450
121	PORTA	23	Inflow	04/26/1999	10:31	04/26/99 10:31	04/26/1999 10:31	450
154	PORTA	23	Inflow	04/29/1999	9:09	04/29/99 09:09	04/29/1999 9:09	700
622	PORTA	23	Inflow	04/30/1999	12:39	04/30/99 12:39	04/30/1999 12:39	490
640	PORTA	23	Inflow	04/30/1999	12:42	04/30/99 12:42	04/30/1999 12:42	740
690	PORTA	23	Inflow	05/04/1999	13:05	05/04/99 13:05	05/04/1999 13:05	750
720	PORTA	23	Inflow	05/05/1999	12:40	05/05/99 12:40	05/05/1999 12:40	755
730	PORTA	23	Inflow	05/06/1999	9:02	05/06/99 09:02	05/06/1999 9:02	260
731	PORTA	23	Inflow	05/06/1999	9:04	05/06/99 09:04	05/06/1999 9:04	740
781	PORTA	23	Inflow	05/10/1999	9:54	05/10/99 09:54	05/10/1999 9:54	100
782	PORTA	23	Inflow	05/10/1999	9:56	05/10/99 09:56	05/10/1999 9:56	780
835	PORTA	23	Inflow	05/11/1999	13:49	05/11/99 13:49	05/11/1999 13:49	550
852	PORTA	23	Inflow	05/11/1999	13:53	05/11/99 13:53	05/11/1999 13:53	755
876	PORTA	23	Inflow	05/12/1999	10:49	05/12/99 10:49	05/12/1999 10:49	765
922	PORTA	23	Inflow	05/12/1999	17:31	05/12/99 17:31	05/12/1999 17:31	600
933	PORTA	23	Inflow	05/13/1999	10:29	05/13/99 10:29	05/13/1999 10:29	760
997	PORTA	23	Inflow	05/17/1999	9:52:00 AM	05/17/99 09:52	05/17/1999 9:52	550
998	PORTA	23	Inflow	05/17/1999	9:53:00 AM	05/17/99 09:53	05/17/1999 9:53	760
1047	PORTA	23	Inflow	05/18/1999	4:07:00 PM	05/18/99 16:07	05/18/1999 16:07	750
1099	PORTA	23	Inflow	05/19/1999	9:29:00 AM	05/19/99 09:29	05/19/1999 9:29	760
1142	PORTA	23	Inflow	05/20/1999	10:04:00 AM	05/20/99 10:04	05/20/1999 10:04	670
1207	PORTA	23	Inflow	05/24/1999	10:43:00 AM	05/24/99 10:43	05/24/1999 10:43	380
1208	PORTA	23	Inflow	05/24/1999	10:44:00 AM	05/24/99 10:44	05/24/1999 10:44	800
1209	PORTA	23	Inflow	05/24/1999	10:45:00 AM	05/24/99 10:45	05/24/1999 10:45	800
1323	PORTA	23	Inflow	05/25/1999	8:49:00 AM	05/25/99 08:49	05/25/1999 8:49	555
1324	PORTA	23	Inflow	05/25/1999	8:50:00 AM	05/25/99 08:50	05/25/1999 8:50	710
1325	PORTA	23	Inflow	05/25/1999	8:51:00 AM	05/25/99 08:51	05/25/1999 8:51	710
1338	PORTA	23	Inflow	05/28/1999	1:12:00 PM	05/28/99 13:12	05/28/1999 13:12	770
1339	PORTA	23	Inflow	05/28/1999	1:13:00 PM	05/28/99 13:13	05/28/1999 13:13	770
1340	PORTA	23	Inflow	05/28/1999	1:14:00 PM	05/28/99 13:14	05/28/1999 13:14	770
1408	PORTA	23	Inflow	06/01/1999	11:05:00 AM	06/01/99 11:05	06/01/1999 11:05	800
1409	PORTA	23	Inflow	06/01/1999	11:06:00 AM	06/01/99 11:06	06/01/1999 11:06	800
1410	PORTA	23	Inflow	06/01/1999	11:07:00 AM	06/01/99 11:07	06/01/1999 11:07	780
1487	PORTA	23	Inflow	06/03/1999	3:13:00 PM	06/03/99 15:13	06/03/1999 15:13	190
1488	PORTA	23	Inflow	06/03/1999	3:14:00 PM	06/03/99 15:14	06/03/1999 15:14	780
1489	PORTA	23	Inflow	06/03/1999	3:15:00 PM	06/03/99 15:15	06/03/1999 15:15	800
1579	PORTA	23	Inflow	06/07/1999	10:16:00 AM	06/07/99 10:16	06/07/1999 10:16	550
1580	PORTA	23	Inflow	06/07/1999	10:17:00 AM	06/07/99 10:17	06/07/1999 10:17	765
1581	PORTA	23	Inflow	06/07/1999	10:18:00 AM	06/07/99 10:18	06/07/1999 10:18	765
1651	PORTA	23	Inflow	06/09/1999	11:05:00 AM	06/09/99 11:05	06/09/1999 11:05	780
1652	PORTA	23	Inflow	06/09/1999	11:06:00 AM	06/09/99 11:06	06/09/1999 11:06	775
1653	PORTA	23	Inflow	06/09/1999	11:07:00 AM	06/09/99 11:07	06/09/1999 11:07	775


Appendix B: Cell 7 Flows
Flow Rate (mL/min)
600
500
400
300
200
100
0
03/31/1999 0:00
04/10/1999 0:00
04/20/1999 0:00
04/30/1999 0:00
05/10/1999 0:00
05/20/1999 0:00
05/30/1999 0:00
06/09/1999 0:00
06/19/1999 0:00
Date/Time

Appendix B: Cell 10 Flows



DFBApp B.xls



Appendix B: Cell 23 Flows
1200
1000
800
600
400
200
0
Flow Rate (mL/min)
03/31/1999 0:00
04/10/1999 0:00
04/20/1999 0:00
04/30/1999 0:00
05/10/1999 0:00
05/20/1999 0:00
05/30/1999 0:00
06/09/1999 0:00
06/19/1999 0:00
Date/Time

DFBApp B.xls

Appendix B

Porta-PSTA Tracer Test Data - Cell 7

Volume of NaBr Solution Applied:	**1.60 L**	**Nominal HRT:**	**14.01 d**
Concentration of Br^- Applied:	**438,439 mg/L**	**Avg. Flow:**	**0.28 m^3/d**
Mass of Br^- Applied:	**702 g**	**Avg. HLR:**	**4.6 cm/d**
Date/Time of Application:	**04/19/1999 17:45**	**Nominal Volume:**	**3.876 m^3**

Porta PSTA #7

Sample ID	Date/Time Sampled	Time (days)	Meas mV	Meas Temp	Calc Conc (mg/L)	Corr Conc (mg/L)	Flow Rate (m3/d)	f(t)	C(t)dt	f(t)dt	QC(t)dt	tf(t)dt	$f(t)dt(t-\tau)^2$
7-1	04/19/1999 17:45	0.00	-66	24.9	4.3	0.0	0.35	0.00	0.00	0.00	0.00	0.00	0.00
7-4	04/20/1999 5:45	0.50	-97	24.9	16.8	12.5	0.26	0.00	3.13	0.00	0.95	0.00	0.37
7-8	04/20/1999 21:45	1.17	-120	24.9	46.3	42.0	0.14	0.01	18.17	0.01	3.66	0.01	2.02
7-12	04/21/1999 13:45	1.83	-129	24.9	68.8	64.5	0.33	0.02	35.49	0.01	8.34	0.02	3.66
7-16	04/22/1999 5:45	2.50	-137	25.0	97.8	93.5	0.08	0.03	52.67	0.02	10.78	0.04	5.01
7-20	04/22/1999 21:45	3.17	-141	24.9	116.7	112.4	0.32	0.04	68.63	0.02	13.67	0.07	6.01
7-24	04/23/1999 13:45	3.83	-143	24.9	127.4	123.1	0.38	0.04	78.49	0.03	27.16	0.10	6.30
7-28	04/24/1999 5:58	4.51	-143	25.0	127.4	123.1	0.39	0.04	83.18	0.03	31.66	0.12	6.10
7-32	04/24/1999 21:58	5.18	-143	25.0	127.4	123.1	0.40	0.04	82.07	0.03	32.05	0.14	5.47
7-36	04/25/1999 13:58	5.84	-143	24.9	127.4	123.1	0.41	0.04	82.07	0.03	32.86	0.16	4.95
7-40	04/26/1999 5:58	6.51	-142	24.9	121.9	117.6	0.42	0.04	80.24	0.03	32.92	0.18	4.36
7-44	04/26/1999 21:58	7.18	-141	24.9	116.7	112.4	0.37	0.04	76.66	0.03	30.29	0.19	3.72
7-48	04/27/1999 13:58	7.84	-140	24.9	111.6	107.3	0.33	0.04	73.24	0.03	25.98	0.19	3.16
7-52	04/28/1999 22:45	9.21	-136	24.9	93.6	89.3	0.25	0.03	134.32	0.05	39.35	0.41	4.78
7-56	04/29/1999 14:45	9.87	-135	24.9	89.6	85.3	0.21	0.03	58.20	0.02	13.46	0.20	1.67
7-60	04/30/1999 6:45	10.54	-134	24.9	85.7	81.4	0.17	0.03	55.57	0.02	10.60	0.20	1.37
7-70	05/01/1999 23:30	12.24	-133	25.1	82.0	77.7	0.22	0.03	135.13	0.05	26.22	0.55	2.46
7-80	05/03/1999 15:30	13.91	-132	25.1	78.5	74.2	0.08	0.03	126.62	0.04	18.52	0.59	1.35
7-90	05/05/1999 7:30	15.57	-133	25.1	82.0	77.7	0.07	0.03	126.62	0.04	9.39	0.66	0.65
7-100	05/06/1999 23:30	17.24	-130	25.0	71.9	67.6	0.24	0.03	121.10	0.04	18.74	0.70	0.20
7-110	05/08/1999 15:30	18.91	-129	24.9	68.8	64.5	0.39	0.02	110.07	0.04	34.47	0.70	0.01
7-120	05/10/1999 7:30	20.57	-129	24.9	68.8	64.5	0.37	0.02	107.49	0.04	41.00	0.75	0.05
7-130	05/11/1999 23:30	22.24	-126	24.9	60.3	56.0	0.24	0.02	100.39	0.04	30.82	0.76	0.29
7-140	05/13/1999 15:30	23.91	-125	24.9	57.7	53.4	0.31	0.02	91.14	0.03	25.23	0.75	0.66
7-150	05/16/1999 3:30	26.41	-124	25.0	55.2	50.9	0.10	0.02	130.36	0.05	27.08	1.16	2.01
7-160	05/19/1999 11:30	29.74	-124	25.0	55.2	50.9	0.28	0.02	169.67	0.06	32.39	1.69	5.45
7-170	05/22/1999 19:30	33.07	-123	25.0	52.8	48.5	0.15	0.02	165.71	0.06	35.47	1.84	9.70
7-181	05/26/1999 11:30	36.74	-123	25.1	52.8	48.5	0.42	0.02	177.92	0.06	50.95	2.20	16.86
Extrap.	06/06/1999 22:33	48.20	-66	--	4.3	0.0	0.35	0.01	278.05	0.10	107.51	4.18	56.35
								0.76	**2822.41**	**1.00**	**771.53**	**18.55**	**154.99**
										M_0		**M_1**	**M_2**

Mass Recovery 110%

Excel Solver Routine Used to determine Peclet Number. (Pe = $1/\mathscr{D}$)

Mean Residence Time τ_a (d) =	**18.55**	**M_1/M_0**
σ^2 (d^2) =	**154.99**	**M_2/M_0**
Number of Tanks N =	**2.22**	**τ_a^2/σ^2**
Volumetric Efficiency =	**1.32**	**τ_a/τ_v**
Dimensionless Variance =	**0.4503**	**1/N**
Wetland Dispersion Number $\mathscr{D}$ =	**0.3271**	**Solver**

Dimensionless Variance Guess

Pe = 3.05687772 0.45029948

$\mathscr{D}$

0.3271

Dimensionless Variance = 2/Pe - 2/Pe^2(1 - exp(-Pe))

Appendix B
Porta-PSTA Tracer Test Data - Cell 7

Volume of LiCl Solution Applied:	**0.025 L**	**Nominal HRT:**	**14.01 d**
Concentration of Li^+ Applied:	**78,457 mg/L**	**Avg. Flow:**	**0.28 m^3/d**
Mass of Li^+ Applied:	**1.96 g**	**Avg. HLR:**	**4.6 cm/d**
Date/Time of Application:	**04/19/1999 17:45**	**Nominal Volume:**	**3.876 m^3**

Porta PSTA #7

Sample ID	Date/Time Sampled	Time (days)	Calc Conc (mg/L)	Corr Conc (mg/L)	Flow Rate (m3/d)	f(t)	C(t)dt	f(t)dt	QC(t)dt	tf(t)dt	f(t)dt(t-τ)^2
7-1	04/19/1999 17:45	0.00	0.025	0.000	0.35	0.00	0.00	0.00	0.00	0.00	0.00
7-4	04/20/1999 5:45	0.50	0.056	0.031	0.26	0.00	0.01	0.00	0.00	0.00	0.43
7-8	04/20/1999 21:45	1.17	0.130	0.105	0.14	0.01	0.05	0.01	0.01	0.01	2.38
7-12	04/21/1999 13:45	1.83	0.180	0.155	0.33	0.02	0.09	0.01	0.02	0.02	4.21
7-16	04/22/1999 5:45	2.50	0.240	0.215	0.08	0.03	0.12	0.02	0.03	0.04	5.52
7-20	04/22/1999 21:45	3.17	0.280	0.255	0.32	0.04	0.16	0.03	0.03	0.07	6.46
7-24	04/23/1999 13:45	3.83	0.300	0.275	0.38	0.04	0.18	0.03	0.06	0.10	6.67
7-28	04/24/1999 5:58	4.51	0.300	0.275	0.39	0.05	0.19	0.03	0.07	0.13	6.41
7-32	04/24/1999 21:58	5.18	0.290	0.265	0.40	0.05	0.18	0.03	0.07	0.15	5.64
7-36	04/25/1999 13:58	5.84	0.280	0.255	0.41	0.04	0.17	0.03	0.07	0.16	4.91
7-40	04/26/1999 5:58	6.51	0.260	0.235	0.42	0.04	0.16	0.03	0.07	0.17	4.17
7-44	04/26/1999 21:58	7.18	0.260	0.235	0.37	0.04	0.16	0.03	0.06	0.18	3.58
7-48	04/27/1999 13:58	7.84	0.240	0.215	0.33	0.04	0.15	0.03	0.05	0.19	3.04
7-52	04/28/1999 22:45	9.21	0.210	0.185	0.25	0.03	0.27	0.05	0.08	0.39	4.57
7-56	04/29/1999 14:45	9.87	0.200	0.175	0.21	0.03	0.12	0.02	0.03	0.19	1.62
7-60	04/30/1999 6:45	10.54	0.190	0.165	0.17	0.03	0.11	0.02	0.02	0.19	1.31
7-70	05/01/1999 23:30	12.24	0.190	0.165	0.22	0.03	0.28	0.05	0.05	0.54	2.38
7-80	05/03/1999 15:30	13.91	0.180	0.155	0.08	0.03	0.27	0.04	0.04	0.58	1.32
7-90	05/05/1999 7:30	15.57	0.180	0.155	0.07	0.03	0.26	0.04	0.02	0.64	0.62
7-100	05/06/1999 23:30	17.24	0.170	0.145	0.24	0.03	0.25	0.04	0.04	0.69	0.19
7-110	05/08/1999 15:30	18.91	0.160	0.135	0.39	0.02	0.23	0.04	0.07	0.71	0.01
7-120	05/10/1999 7:30	20.57	0.150	0.125	0.37	0.02	0.22	0.04	0.08	0.72	0.06
7-130	05/11/1999 23:30	22.24	0.130	0.105	0.24	0.02	0.19	0.03	0.06	0.69	0.27
7-140	05/13/1999 15:30	23.91	0.130	0.105	0.31	0.02	0.17	0.03	0.05	0.68	0.61
7-150	05/16/1999 3:30	26.41	0.140	0.115	0.10	0.02	0.28	0.05	0.06	1.16	2.04
7-160	05/19/1999 11:30	29.74	0.130	0.105	0.28	0.02	0.37	0.06	0.07	1.73	5.63
7-170	05/22/1999 19:30	33.07	0.130	0.105	0.15	0.02	0.35	0.06	0.07	1.84	9.76
7-181	05/26/1999 11:30	36.74	0.130	0.105	0.42	0.02	0.39	0.06	0.11	2.25	17.36
Extrap.	06/06/1999 22:33	48.20	0.025	0.000	0.35	0.01	0.60	0.10	0.23	4.29	57.94
						0.76	**5.96**	**1.00**	**1.63**	**18.51**	**159.09**
								M_0		**M_1**	**M_2**
								Mass Recovery	**83%**		

Excel Solver Routine Used to determine Peclet Number. (Pe = 1/𝒟)

Mean Residence Time τ_a (d) =	**18.51**	**M_1/M_0**
σ^2 (d^2) =	**159.09**	**M_2/M_0**
Number of Tanks N =	**2.15**	**τ_a^2/σ^2**
Volumetric Efficiency =	**1.32**	**τ_α/τ_ν**
Dimensionless Variance =	**0.4644**	**1/N**
Wetland Dispersion Number 𝒟 =	**0.3442**	**Solver**

Dimensionless Variance Guess

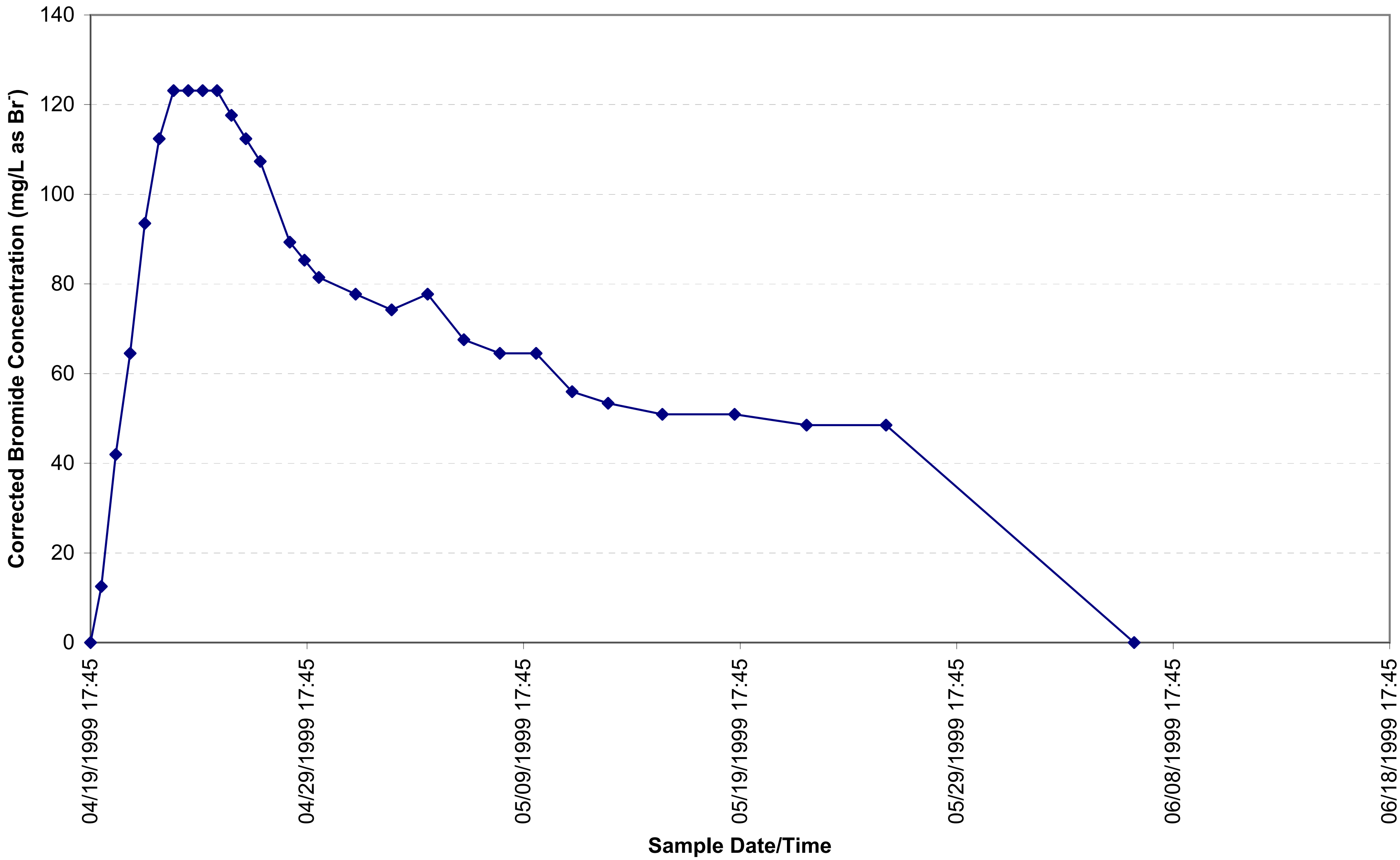
Pe = 2.905521401 0.464399188

𝒟

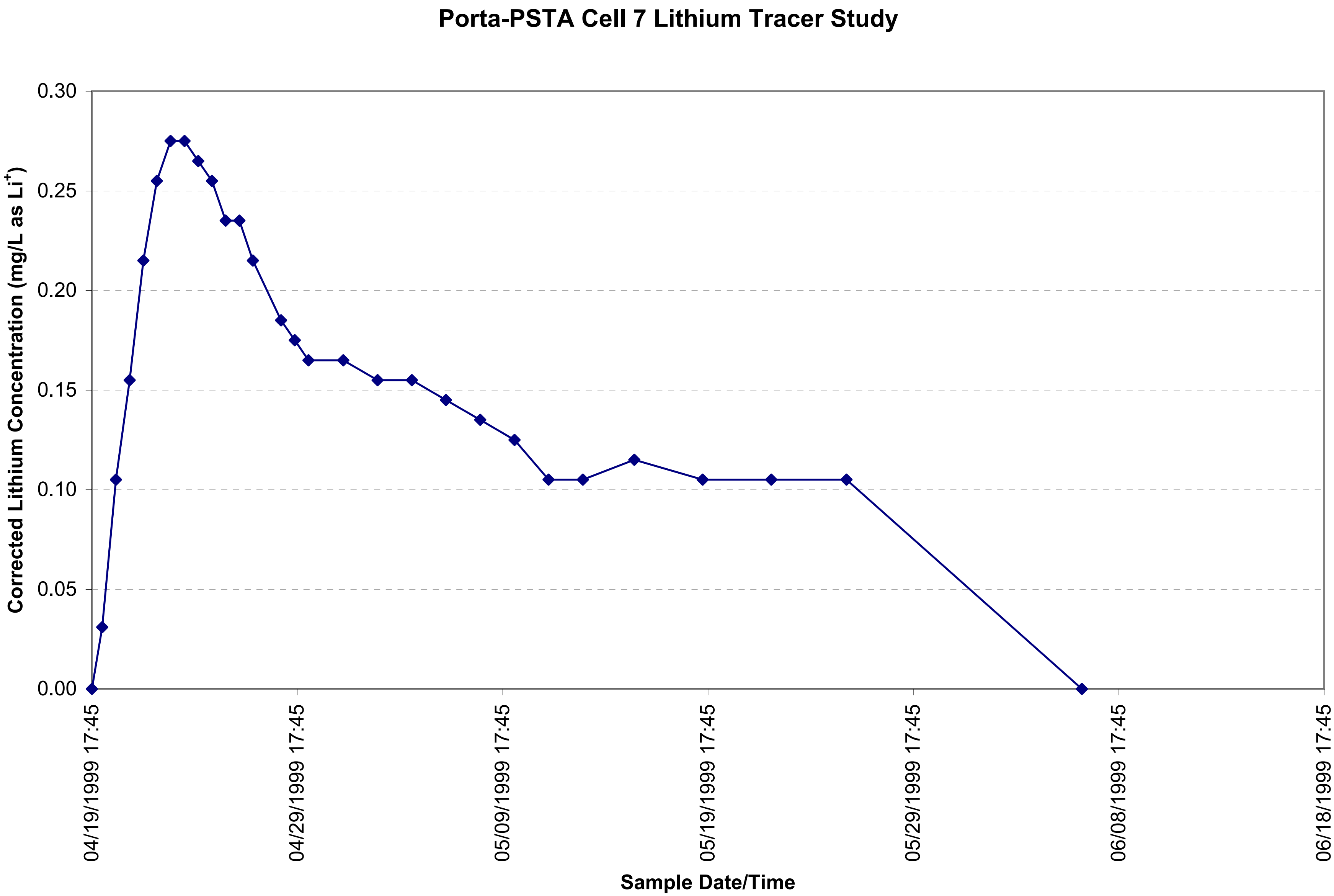
0.3442

Dimensionless Variance = 2/Pe - 2/Pe^2(1 - exp(-Pe))

Porta-PSTA Cell 7 Bromide Tracer Study



DFB/App B.xls



Porta-PSTA Cell 7 Lithium Tracer Study
Corrected Lithium Concentration (mg/L as Li+)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
04/19/1999 17:45
04/29/1999 17:45
05/09/1999 17:45
05/19/1999 17:45
05/29/1999 17:45
06/08/1999 17:45
06/18/1999 17:45
Sample Date/Time

DFB/App B.xls

Porta-PSTA Tracer Test - Cell 10

Volume of NaBr Solution Applied:	**0.80 L**	**Nominal HRT:**	**8.17 d**
Concentration of Br^- Applied:	**438,439 mg/L**	**Avg. Flow:**	**0.27 m^3/d**
Mass of Br^- Applied:	**351 g**	**Avg. HLR:**	**4.4 cm/d**
Date/Time of Application:	**04/19/1999 17:45**	**Nominal Volume:**	**2.178 m^3**

Porta PSTA #10

Sample ID	Date/Time Sampled	Time (days)	Meas mV	Meas Temp	Calc Conc (mg/L)	Corr Conc (mg/L)	Flow Rate (m3/d)	f(t)	C(t)dt	f(t)dt	QC(t)dt	tf(t)dt	$f(t)dt(t-\tau)^2$
10-1	04/19/1999 17:45	0.00	-59	25.0	3.2	0.0	0.43	0.00	0.00	0.00	0.00	0.00	0.00
10-4	04/20/1999 5:45	0.50	-121	25.0	48.4	45.2	0.41	0.01	11.30	0.01	4.73	0.00	1.49
10-8	04/20/1999 21:45	1.17	-133	25.0	82.0	78.9	0.38	0.04	41.36	0.03	16.35	0.02	5.03
10-12	04/21/1999 13:45	1.83	-135	25.0	89.6	86.4	0.36	0.05	55.10	0.04	20.46	0.05	6.06
10-16	04/22/1999 5:45	2.50	-134	25.0	85.7	82.6	0.37	0.05	56.33	0.04	20.45	0.08	5.59
10-20	04/22/1999 21:45	3.17	-134	24.9	85.7	82.6	0.21	0.05	55.05	0.04	15.91	0.10	4.89
10-24	04/23/1999 13:45	3.83	-134	24.9	85.7	82.6	0.38	0.05	55.05	0.04	16.24	0.12	4.36
10-28	04/24/1999 5:58	4.51	-134	24.9	85.7	82.6	0.29	0.05	55.79	0.04	18.57	0.15	3.90
10-32	04/24/1999 21:58	5.18	-134	24.9	85.7	82.6	0.20	0.05	55.05	0.04	13.41	0.17	3.37
10-36	04/25/1999 13:58	5.84	-134	24.9	85.7	82.6	0.11	0.05	55.05	0.04	8.53	0.19	2.93
10-40	04/26/1999 5:58	6.51	-135	24.9	89.6	86.4	0.02	0.05	56.33	0.04	3.73	0.22	2.57
10-44	04/26/1999 21:58	7.18	-134	24.9	85.7	82.6	0.35	0.05	56.33	0.04	10.51	0.25	2.19
10-48	04/27/1999 13:58	7.84	-133	24.9	82.0	78.9	0.35	0.05	53.81	0.03	18.83	0.26	1.75
10-52	04/28/1999 23:25	9.24	-130	25.0	71.9	68.7	0.34	0.05	102.86	0.07	35.62	0.56	2.44
10-56	04/29/1999 15:25	9.90	-127	25.1	63.0	59.8	0.34	0.04	42.85	0.03	14.68	0.26	0.70
10-60	04/30/1999 7:25	10.57	-126	24.9	60.3	57.1	0.34	0.04	38.98	0.02	13.26	0.25	0.48
10-70	05/01/1999 23:30	12.24	-121	25.1	48.4	45.2	0.21	0.03	85.45	0.05	23.61	0.62	0.57
10-80	05/03/1999 15:30	13.91	-118	25.1	42.4	39.2	0.07	0.03	70.36	0.04	10.11	0.59	0.11
10-90	05/05/1999 7:30	15.57	-117	25.1	40.6	37.4	0.36	0.02	63.86	0.04	13.71	0.60	0.00
10-100	05/06/1999 23:30	17.24	-114	25.2	35.5	32.4	0.17	0.02	58.15	0.04	15.22	0.61	0.11
10-110	05/11/1999 19:30	22.07	-108	25.2	27.3	24.1	0.27	0.02	136.58	0.09	29.74	1.71	2.18
10-120	05/13/1999 11:30	23.74	-104	25.2	22.9	19.7	0.37	0.01	36.55	0.02	11.68	0.53	1.59
10-130	05/15/1999 19:30	26.07	-103	25.2	21.9	18.7	0.24	0.01	44.88	0.03	13.81	0.71	3.01
10-140	05/19/1999 3:30	29.41	-101	25.2	20.1	16.9	0.30	0.01	59.39	0.04	16.03	1.05	6.48
10-150	05/22/1999 11:30	32.74	-98	25.2	17.6	14.4	0.17	0.01	52.18	0.03	12.08	1.03	8.96
10-162	05/26/1999 11:30	36.74	-94	25.2	14.7	11.6	0.37	0.01	51.98	0.03	14.02	1.15	13.36
10-163	06/01/1999 15:35	42.91	-88	25.6	11.3	8.2	0.32	0.01	60.88	0.04	21.09	1.54	24.57
10-164	06/09/1999 16:45	50.96	-77	25.5	7.0	3.8	0.00	0.00	48.18	0.03	7.73	1.44	31.97
Extrap.	06/15/1999 13:25	56.82	-59	--	3.2	0.0	0.00	0.00	11.18	0.01	0.00	0.38	10.96
								0.90	**1570.88**	**1.00**	**420.13**	**14.65**	**151.61**
										M_0		**M_1**	**M_2**

Mass Recovery 120%

Excel Solver Routine Used to determine Peclet Number. (Pe = 1/$\mathcal{D}$)

Mean Residence Time τ_a (d) =	**14.65**	**M_1/M_0**
σ^2 (d^2) =	**151.61**	**M_2/M_0**
Number of Tanks N =	**1.42**	**τ_a^2/σ^2**
Volumetric Efficiency =	**1.79**	**τ_α/τ_v**
Dimensionless Variance =	**0.7066**	**1/N**
Wetland Dispersion Number $\mathcal{D}$ =	**0.8731**	**Solver**

Dimensionless Variance Guess

Pe = 1.14530772 0.70659939

$\mathcal{D}$

0.8731

Dimensionless Variance = 2/Pe - 2/Pe^2(1 - exp(-Pe))

Porta-PSTA Tracer Test - Cell 10

Volume of LiCl Solution Applied:	**0.010 L**	**Nominal HRT:**	**8.17 d**
Concentration of Li^+ Applied:	**78,457 mg/L**	**Avg. Flow:**	**0.27 m^3/d**
Mass of Li^+ Applied:	**0.78 g**	**Avg. HLR:**	**4.4 cm/d**
Date/Time of Application:	**04/19/1999 17:45**	**Nominal Volume:**	**2.178 m^3**

Porta PSTA #10

Sample ID	Date/Time Sampled	Time (days)	Calc Conc (mg/L)	Corr Conc (mg/L)	Flow Rate (m3/d)	f(t)	C(t)dt	f(t)dt	QC(t)dt	tf(t)dt	$f(t)dt(t-\tau)^2$
10-1	04/19/1999 17:45	0.00	0.028	0.000	0.43	0.00	0.00	0.00	0.00	0.00	0.00
10-4	04/20/1999 5:45	0.50	0.100	0.072	0.41	0.01	0.02	0.01	0.01	0.00	1.30
10-8	04/20/1999 21:45	1.17	0.180	0.152	0.38	0.04	0.07	0.03	0.03	0.02	4.95
10-12	04/21/1999 13:45	1.83	0.180	0.152	0.36	0.05	0.10	0.04	0.04	0.05	6.08
10-16	04/22/1999 5:45	2.50	0.180	0.152	0.37	0.05	0.10	0.04	0.04	0.08	5.47
10-20	04/22/1999 21:45	3.17	0.170	0.142	0.21	0.05	0.10	0.03	0.03	0.10	4.74
10-24	04/23/1999 13:45	3.83	0.170	0.142	0.38	0.05	0.09	0.03	0.03	0.12	4.07
10-28	04/24/1999 5:58	4.51	0.160	0.132	0.29	0.05	0.09	0.03	0.03	0.14	3.51
10-32	04/24/1999 21:58	5.18	0.170	0.142	0.20	0.05	0.09	0.03	0.02	0.16	3.03
10-36	04/25/1999 13:58	5.84	0.170	0.142	0.11	0.05	0.09	0.03	0.01	0.18	2.73
10-40	04/26/1999 5:58	6.51	0.170	0.142	0.02	0.05	0.09	0.03	0.01	0.21	2.34
10-44	04/26/1999 21:58	7.18	0.180	0.152	0.35	0.05	0.10	0.03	0.02	0.24	2.05
10-48	04/27/1999 13:58	7.84	0.170	0.142	0.35	0.05	0.10	0.03	0.03	0.26	1.72
10-52	04/28/1999 23:25	9.24	0.160	0.132	0.34	0.05	0.19	0.07	0.07	0.57	2.44
10-56	04/29/1999 15:25	9.90	0.140	0.112	0.34	0.04	0.08	0.03	0.03	0.27	0.71
10-60	04/30/1999 7:25	10.57	0.140	0.112	0.34	0.04	0.07	0.03	0.03	0.27	0.49
10-70	05/01/1999 23:30	12.24	0.120	0.092	0.21	0.04	0.17	0.06	0.05	0.68	0.60
10-80	05/03/1999 15:30	13.91	0.110	0.082	0.07	0.03	0.14	0.05	0.02	0.67	0.11
10-90	05/05/1999 7:30	15.57	0.100	0.072	0.36	0.03	0.13	0.05	0.03	0.66	0.00
10-100	05/06/1999 23:30	17.24	0.087	0.059	0.17	0.02	0.11	0.04	0.03	0.63	0.13
10-110	05/11/1999 19:30	22.07	0.070	0.042	0.27	0.02	0.24	0.09	0.05	1.68	2.21
10-120	05/13/1999 11:30	23.74	0.063	0.035	0.37	0.01	0.06	0.02	0.02	0.52	1.56
10-130	05/15/1999 19:30	26.07	0.059	0.031	0.24	0.01	0.08	0.03	0.02	0.67	2.89
10-140	05/19/1999 3:30	29.41	0.060	0.032	0.30	0.01	0.11	0.04	0.03	1.02	6.39
10-150	05/22/1999 11:30	32.74	0.054	0.026	0.17	0.01	0.10	0.03	0.02	1.05	9.24
10-162	05/26/1999 11:30	36.74	0.050	0.022	0.37	0.01	0.10	0.03	0.03	1.17	13.70
10-163	06/01/1999 15:35	42.91	0.046	0.018	0.32	0.01	0.12	0.04	0.04	1.72	27.61
10-164	06/09/1999 16:45	50.96	0.030	0.002	0.00	0.00	0.08	0.03	0.01	1.33	29.58
Extrap.	06/15/1999 13:25	56.82	0.028	0.000	0.00	0.00	0.01	0.00	0.00	0.11	3.18
						0.89	**2.85**	**1.00**	**0.77**	**14.57**	**142.84**
								M_0		**M_1**	**M_2**

Mass Recovery **98%**

Excel Solver Routine Used to determine Peclet Number. (Pe = 1/$\mathscr{D}$)

Mean Residence Time τ_a (d) =	**14.57**	**M_1/M_0**
σ^2 (d^2) =	**142.84**	**M_2/M_0**
Number of Tanks N =	**1.49**	**τ_a^2/σ^2**
Volumetric Efficiency =	**1.78**	**τ_a/τ_v**
Dimensionless Variance =	**0.6727**	**1/N**
Wetland Dispersion Number $\mathscr{D}$ =	**0.7536**	**Solver**

Dimensionless Variance Guess

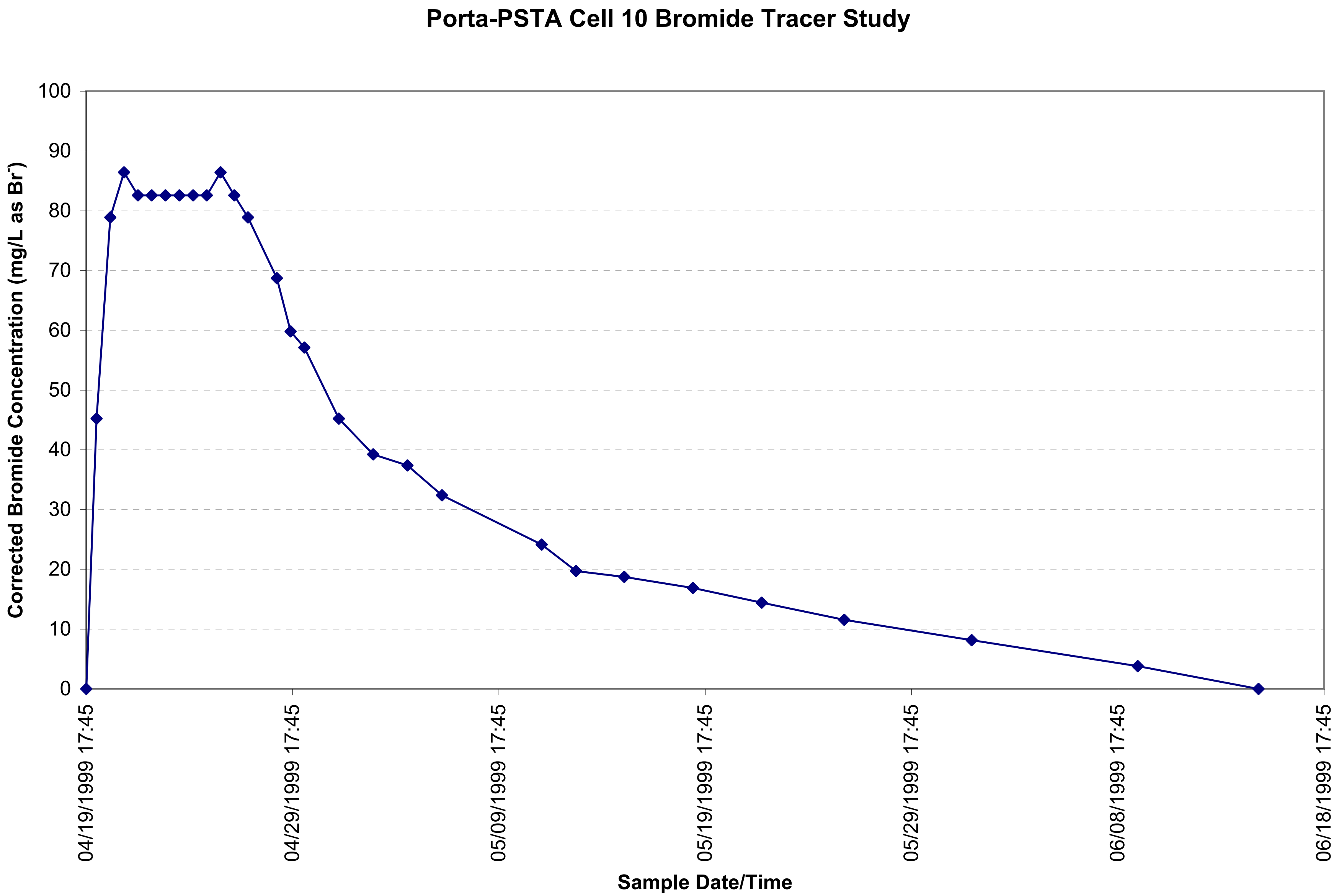
Pe = 1.3268968 0.672699674

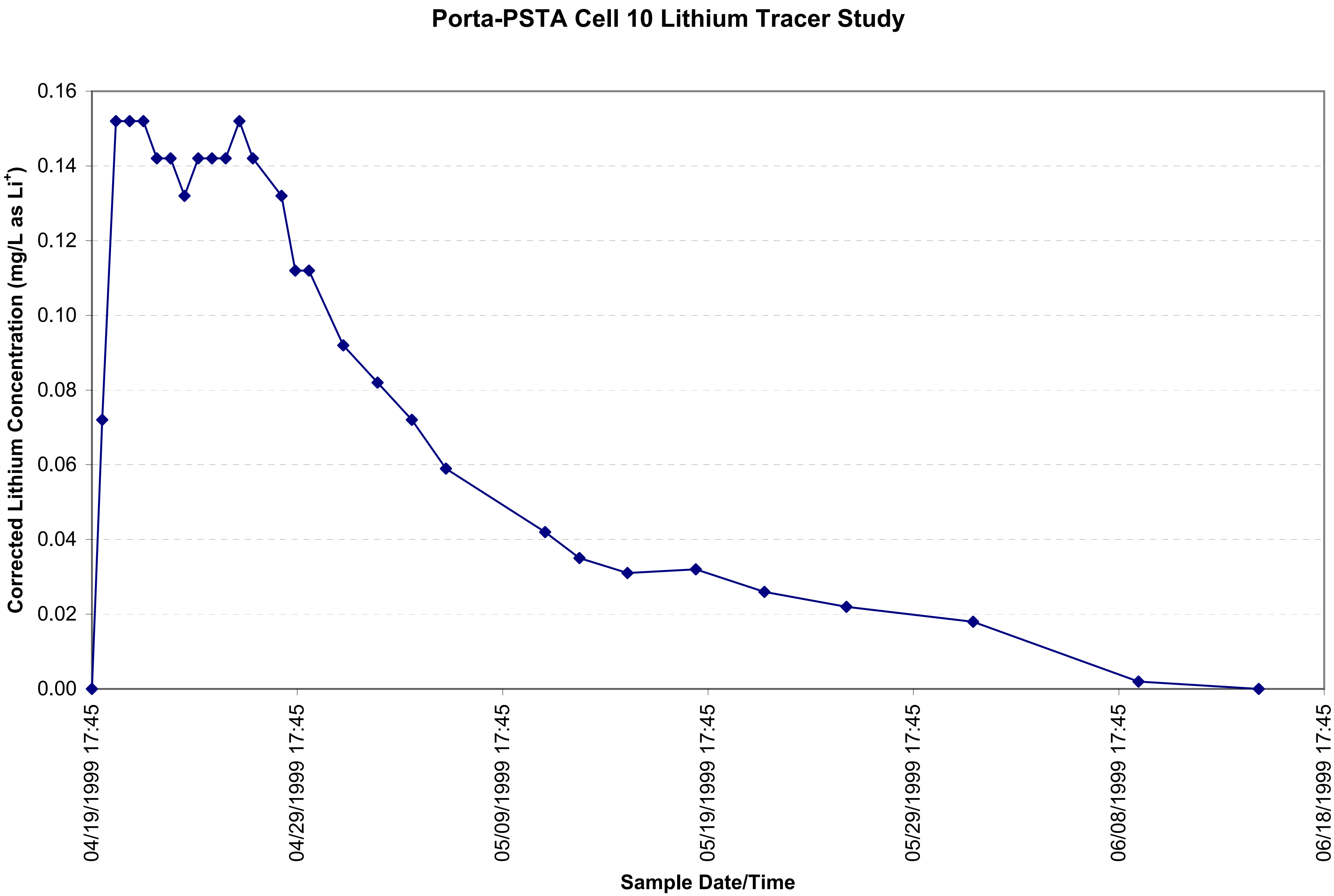
$\mathscr{D}$

0.7536

Dimensionless Variance = 2/Pe - 2/Pe^2(1 - exp(-Pe))

Porta-PSTA Cell 10 Bromide Tracer Study




Porta-PSTA Cell 10 Lithium Tracer Study
Corrected Lithium Concentration (mg/L as Li+)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
04/19/1999 17:45
04/29/1999 17:45
05/09/1999 17:45
05/19/1999 17:45
05/29/1999 17:45
06/08/1999 17:45
06/18/1999 17:45
Sample Date/Time

DFB/App B.xls

Porta-PSTA Tracer Test - Cell 23

Volume of NaBr Solution Applied:	**2.50 L**	**Nominal HRT:**	**6.42**	**d**
Concentration of Br^- Applied:	**438,439 mg/L**	**Avg. Flow:**	**0.96**	**m^3/d**
Mass of Br^- Applied:	**1096 g**	**Avg. HLR:**	**5.3**	**cm/d**
Date/Time of Application:	**04/19/1999 17:45**	**Nominal Volume:**	**6.138**	**m^3**

Porta PSTA #23

Sample ID	Date/Time Sampled	Time (days)	Meas mV	Meas Temp	Calc Conc (mg/L)	Corr Conc (mg/L)	Flow Rate (m3/d)	f(t)	C(t)dt	f(t)dt	QC(t)dt	tf(t)dt	$f(t)dt(t-\tau)^2$
23-1	04/19/1999 17:45	0.00	-65	25.1	4.1	0.0	1.08	0.00	0.00	0.00	0.00	0.00	0.00
23-4	04/20/1999 5:45	0.50	-112	25.1	32.5	28.4	1.08	0.01	7.11	0.01	7.66	0.00	2.04
23-8	04/20/1999 21:45	1.17	-118	25.1	42.4	38.3	1.07	0.03	22.24	0.02	23.85	0.02	5.96
23-10	04/22/1999 13:48	2.84	-121	25.1	48.4	44.3	0.96	0.04	68.86	0.07	70.04	0.14	15.90
23-12	04/23/1999 13:10	3.81	-123	25.2	52.8	48.7	1.03	0.05	45.26	0.05	45.05	0.15	8.70
23-16	04/28/1999 19:30	9.07	-116	25.2	38.8	34.7	0.94	0.04	219.53	0.22	215.70	1.43	25.27
23-20	04/29/1999 11:30	9.74	-116	25.2	38.8	34.7	0.98	0.04	23.13	0.02	22.21	0.22	1.39
23-24	04/30/1999 3:30	10.41	-114	25.2	35.5	31.4	0.81	0.03	22.04	0.02	19.71	0.22	1.10
23-30	05/01/1999 3:30	11.41	-110	25.1	29.8	25.7	1.07	0.03	28.56	0.03	26.76	0.32	1.11
23-40	05/02/1999 19:30	13.07	-109	25.1	28.5	24.4	1.07	0.03	41.75	0.04	44.70	0.52	1.00
23-50	05/04/1999 11:30	14.74	-109	25.1	28.5	24.4	1.08	0.02	40.68	0.04	43.80	0.57	0.42
23-60	05/06/1999 3:30	16.41	-106	25.1	25.0	20.9	0.57	0.02	37.74	0.04	31.09	0.60	0.09
23-70	05/07/1999 19:30	18.07	-106	25.1	25.0	20.9	0.74	0.02	34.80	0.04	22.72	0.61	0.00
23-80	05/09/1999 11:30	19.74	-107	25.1	26.1	22.0	0.36	0.02	35.74	0.04	19.57	0.68	0.12
23-90	05/11/1999 3:30	21.41	-106	25.1	25.0	20.9	0.91	0.02	35.74	0.04	22.72	0.74	0.44
23-100	05/12/1999 19:30	23.07	-102	25.2	21.0	16.8	0.89	0.02	31.44	0.03	28.38	0.71	0.84
23-110	05/14/1999 11:30	24.74	-99	25.2	18.4	14.3	1.02	0.02	25.91	0.03	24.70	0.63	1.21
23-120	05/17/1999 19:30	28.07	-98	25.2	17.6	13.5	1.09	0.01	46.19	0.05	48.61	1.24	4.05
23-130	05/21/1999 3:30	31.41	-98	25.2	17.6	13.5	0.89	0.01	44.87	0.05	44.40	1.35	7.26
23-140	05/24/1999 11:30	34.74	-100	25.3	19.2	15.1	1.14	0.01	47.56	0.05	48.26	1.59	12.29
23-149	06/01/1999 15:30	42.91	-88	25.4	11.3	7.2	1.05	0.01	90.98	0.09	99.70	3.58	43.47
23-150	06/09/1999 16:40	50.95	-73	25.4	5.8	1.7	1.08	0.00	35.97	0.04	38.34	1.71	32.41
Extrap.	06/11/1999 7:54	52.59	-65	--	4.1	0.0	1.08	0.00	1.42	0.00	1.53	0.07	1.73
								0.51	**987.49**	**1.00**	**949.52**	**17.10**	**166.79**
										M_0		**M_1**	**M_2**

Mass Recovery 87%

Excel Solver Routine Used to determine Peclet Number. (Pe = 1/$\mathcal{D}$)

Mean Residence Time τ_a (d) =	**17.10**	**M_1/M_0**
σ^2 (d^2) =	**166.79**	**M_2/M_0**
Number of Tanks N =	**1.75**	**τ_a^2/σ^2**
Volumetric Efficiency =	**2.66**	**τ_α/τ_v**
Dimensionless Variance =	**0.5703**	**1/N**
Wetland Dispersion Number $\mathcal{D}$ =	**0.5049**	**Solver**

Dimensionless Variance Guess

Pe = 1.98062977 0.57029938

$\mathcal{D}$

0.5049

Dimensionless Variance = 2/Pe - 2/Pe^2(1 - exp(-Pe))

Porta-PSTA Tracer Test - Cell 23

Volume of LiCl Solution Applied:	0.035 L	Nominal HRT:	6.46 d
Concentration of Li^+ Applied:	78,457 mg/L	Avg. Flow:	0.95 m^3/d
Mass of Li^+ Applied:	2.75 g	Avg. HLR:	5.3 cm/d
Date/Time of Application:	04/19/1999 17:45	Nominal Volume:	6.138 m^3

Porta PSTA #23

Sample ID	Date/Time Sampled	Time (days)	Calc Conc (mg/L)	Corr Conc (mg/L)	Flow Rate (m3/d)	f(t)	C(t)dt	f(t)dt	QC(t)dt	tf(t)dt	$f(t)dt(t-\tau)^2$
23-1	04/19/1999 17:45	0.00	0.036	0.000	1.08	0.00	0.00	0.00	0.00	0.00	0.00
23-4	04/20/1999 5:45	0.50	0.120	0.084	1.08	0.02	0.02	0.01	0.02	0.00	2.06
23-8	04/20/1999 21:45	1.17	0.150	0.114	1.07	0.05	0.07	0.03	0.07	0.03	5.98
23-10	04/22/1999 13:48	2.84	0.160	0.124	0.96	0.06	0.20	0.09	0.20	0.19	15.09
23-12	04/23/1999 13:10	3.81	0.160	0.124	1.03	0.06	0.12	0.06	0.12	0.19	7.37
23-16	04/28/1999 19:30	9.07	0.120	0.084	0.94	0.05	0.55	0.26	0.54	1.65	17.69
23-20	04/29/1999 11:30	9.74	0.120	0.084	0.98	0.04	0.06	0.03	0.05	0.25	0.75
23-24	04/30/1999 3:30	10.41	0.100	0.064	0.81	0.03	0.05	0.02	0.04	0.23	0.51
23-30	05/01/1999 3:30	11.41	0.094	0.058	1.07	0.03	0.06	0.03	0.06	0.31	0.42
23-40	05/02/1999 19:30	13.07	0.092	0.056	1.07	0.03	0.09	0.04	0.10	0.54	0.28
23-50	05/04/1999 11:30	14.74	0.088	0.052	1.08	0.03	0.09	0.04	0.10	0.58	0.03
23-60	05/06/1999 3:30	16.41	0.087	0.051	0.57	0.02	0.09	0.04	0.07	0.62	0.03
23-70	05/07/1999 19:30	18.07	0.082	0.046	0.74	0.02	0.08	0.04	0.05	0.65	0.23
23-80	05/09/1999 11:30	19.74	0.082	0.046	0.36	0.02	0.08	0.04	0.04	0.68	0.62
23-90	05/11/1999 3:30	21.41	0.079	0.043	0.91	0.02	0.07	0.03	0.05	0.71	1.17
23-100	05/12/1999 19:30	23.07	0.063	0.027	0.89	0.02	0.06	0.03	0.05	0.61	1.52
23-110	05/14/1999 11:30	24.74	0.044	0.008	1.02	0.01	0.03	0.01	0.03	0.33	1.14
23-120	05/17/1999 19:30	28.07	0.057	0.021	1.09	0.01	0.05	0.02	0.05	0.60	3.06
23-130	05/21/1999 3:30	31.41	0.060	0.024	0.89	0.01	0.08	0.04	0.07	1.04	7.86
23-140	05/24/1999 11:30	34.74	0.063	0.027	1.14	0.01	0.09	0.04	0.09	1.31	13.31
23-149	06/01/1999 15:30	42.91	0.051	0.015	1.05	0.01	0.17	0.08	0.19	3.11	46.35
23-150	06/09/1999 16:40	50.95	0.034	-0.002	1.08	0.00	0.05	0.02	0.06	1.15	25.27
						0.54	**2.14**	**1.00**	**2.06**	**14.76**	**150.74**
								M_0		M_1	M_2

Mass Recovery **75%**

Excel Solver Routine Used to determine Peclet Number. (Pe = 1/$\mathscr{D}$)

Mean Residence Time τ_a (d) =	14.76	M_1/M_0
σ^2 (d^2) =	150.74	M_2/M_0
Number of Tanks N =	1.45	τ_a^2/σ^2
Volumetric Efficiency =	2.28	τ_a/τ_v
Dimensionless Variance =	0.6919	1/N
Wetland Dispersion Number $\mathscr{D}$ =	0.8181	Solver

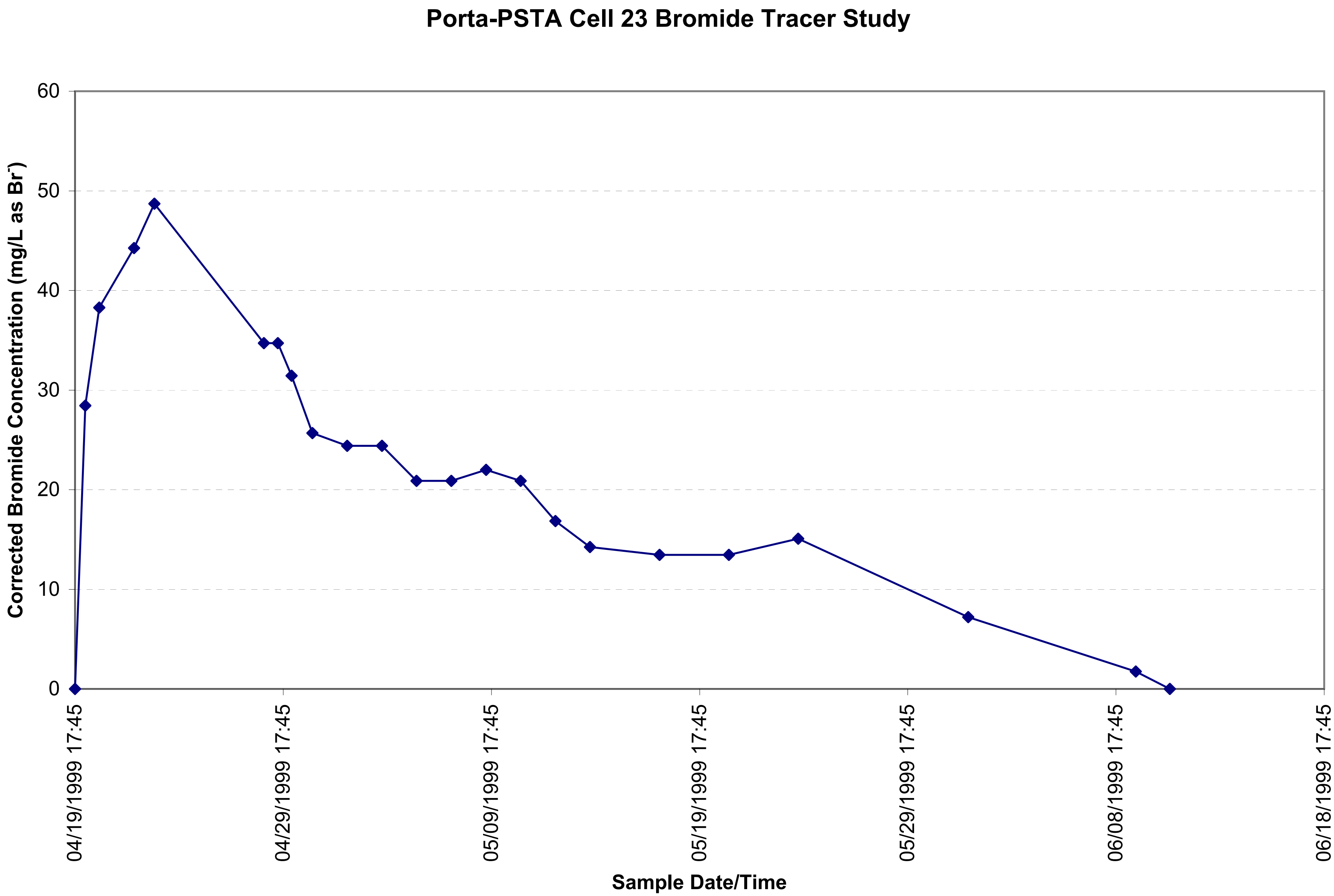
Dimensionless Variance Guess

Pe = 1.222278245 0.691899582

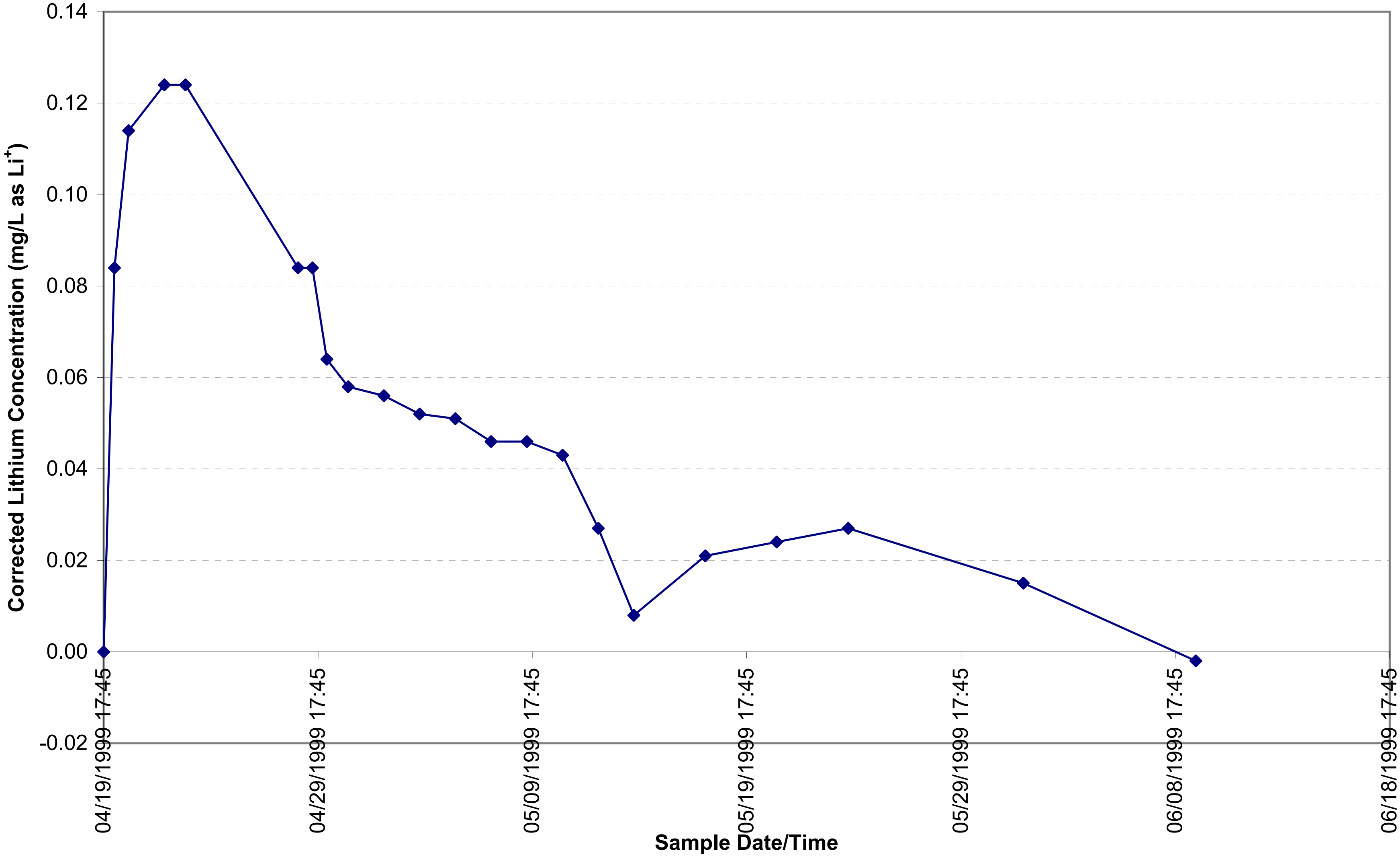
$\mathscr{D}$

0.8181

Dimensionless Variance = 2/Pe - 2/Pe^2(1 - exp(-Pe))


Porta-PSTA Cell 23 Bromide Tracer Study
Corrected Bromide Concentration (mg/L as Br⁻)
0
10
20
30
40
50
60
04/19/1999 17:45
04/29/1999 17:45
05/09/1999 17:45
05/19/1999 17:45
05/29/1999 17:45
06/08/1999 17:45
06/18/1999 17:45
Sample Date/Time

Porta-PSTA Cell 23 Lithium Tracer Study



DFB/App B.xls

APPENDIX C

Preliminary PSTA Forecast Model Manual

Preliminary PSTA Forecast Model Manual

PREPARED FOR: Susan Gray/SFWMD

PREPARED BY: CH2M HILL

DATE: October 4, 1999

Contents

Tables

Introduction

The PSTA Forecast Model (Version 1.0) was developed using Access-97. The algal-phosphorous growth model was initially developed by Dr. Robert Kadlec. The model tracks water mass balances, particulate mass balances, and phosphorous mass balances in an algal-dominated Everglades ecosystem. The model is broken into three overall components:

- The water column
- An active periphyton mat and sediment component
- An inactive sediment component

This version of the PSTA performance model does not incorporate the effect of sunlight on growth, or the effect of temperature. These key forcing functions are now being addressed and entered into Version 1.2, currently under development. The model assumes a constant area is available for the active mat and residuals and all activity is assumed to be dependent upon a relatively thin surface zone.

Why Access?

Many models have been developed using Microsoft Excel as their framework. This model is based around Microsoft Access. While Excel has its advantages, Access offers its own unique qualities as well:

- Access provides a user-friendlier atmosphere with separate pages or forms for textual descriptions or instructions, model parameter inputs, and results. The user does not need to sort through pages of data to find the results of the model run or parameters to change. A click of a button brings a summary to the screen.
- Access has the ability to store and utilize a larger amount of data. While at simpler levels Access may take longer to run the model, Access has the ability to create and store much larger datasets in a smaller amount of space. Individual model runs can be stored by a unique title and later be easily recalled for comparison to new model runs.
- Excel may "ghost" model runs, showing no change in results despite a change in input, especially when running lengthy models. Access will not have this problem. The user will see an indicator the model is running.
- The model user does not need to create comparison or result tables. Access contains forms designed to create report-ready result output. The user will need only to pick the model run(s) desired and Access will generate print ready tables or figures.
- On the design aspect, Access can be adapted to incorporate submodels just as easily as Excel. Additional results or inputs are easily added to existing input forms or result reports.

Overall, while initially an Access-based model may take more time to develop, the end result will be a model that is easier to adapt, manipulate, and interpret.

Model Design

The Version 1.0 PSTA Forecast model is based upon a relatively simple design system. A “Main Menu” form serves as a starting point from the model. Buttons on this page link the different areas of the model together.

Input parameters are manipulated through a single self contained table. The values for this table can be viewed or changed through the “Model Variable Inputs” form. Near the bottom, right-hand corner of the form is button to run the model. Clicking once on this button runs a number of macros and queries. These are the utilities Access uses to make calculations and tables. For the PSTA model, all calculations that are time independent are run first and written to tables. From here, the time dependent calculations are made. The results are written to a single table, and specific values are then pulled into further use in separate tables as needed.

The results can be retrieved from either the Input form, or the Main Menu. The results display all the input parameters, results, and graphs on a single easily readable form. While not available at this point, upon running the model, the user will be asked to give a unique name to the model run that will store those results under that name. Further results pages will then be developed to allow the user to compare any two model runs.

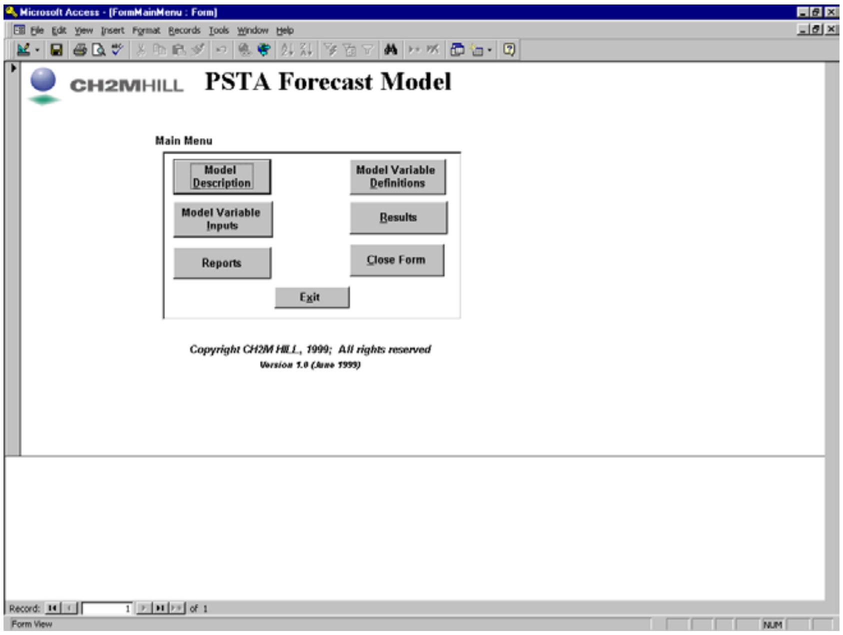
The true heart of the model is contained within the queries and macros that run the model. The tables found at the end of this memo summarize the calculations designed within the queries. For those users with little knowledge of Access database programs, it is suggested any changes that are desired be made through the model designer. However, little knowledge of Access is needed to effectively use the model. The following section covers the basic Access techniques needed.

Basic Access Concepts

A database is essentially a collection of information. It is made up of five basic components: tables, forms, queries, reports, and macros, modules, or events. The tables are used to store related data. Forms serve a variety of purposes including data-entry (Model Variable Input Form), switchboard type options (Main Menu Form), and dialog actions (i.e., “Do you really want to quit?”). Queries are used to view, change, and analyze data. Reports summarize and present data in a printable format. Macros, Modules, and Events are “computer programs” commands. These components tell the database which forms or queries to open when the user clicks on a button.

Starting the Model

To open the model, first open Access, then select the PSTA.mdb file. The model will automatically open to the Main Menu form of the model:



The buttons move to the following locations:

"Model Description": Opens a text form showing the description of the model, which submodels are incorporated, and any other important information on the design of the model.

"Model Variable Description": Opens forms containing tables showing the name, descriptions, units, and abbreviation for all the variables.

"Model Variable Inputs": This form contains tables for all variables that may be manipulated.

"Results": Moves the user to the form displaying the results of the most recent model run.

"Reports": Provides the user with options for reports to print. Buttons on this page will automatically generate reports for a single model run, or comparison of model runs.

"Close Form": Only for users with Access knowledge. This button will close the main menu form and allow the user to move amongst the components of the model.

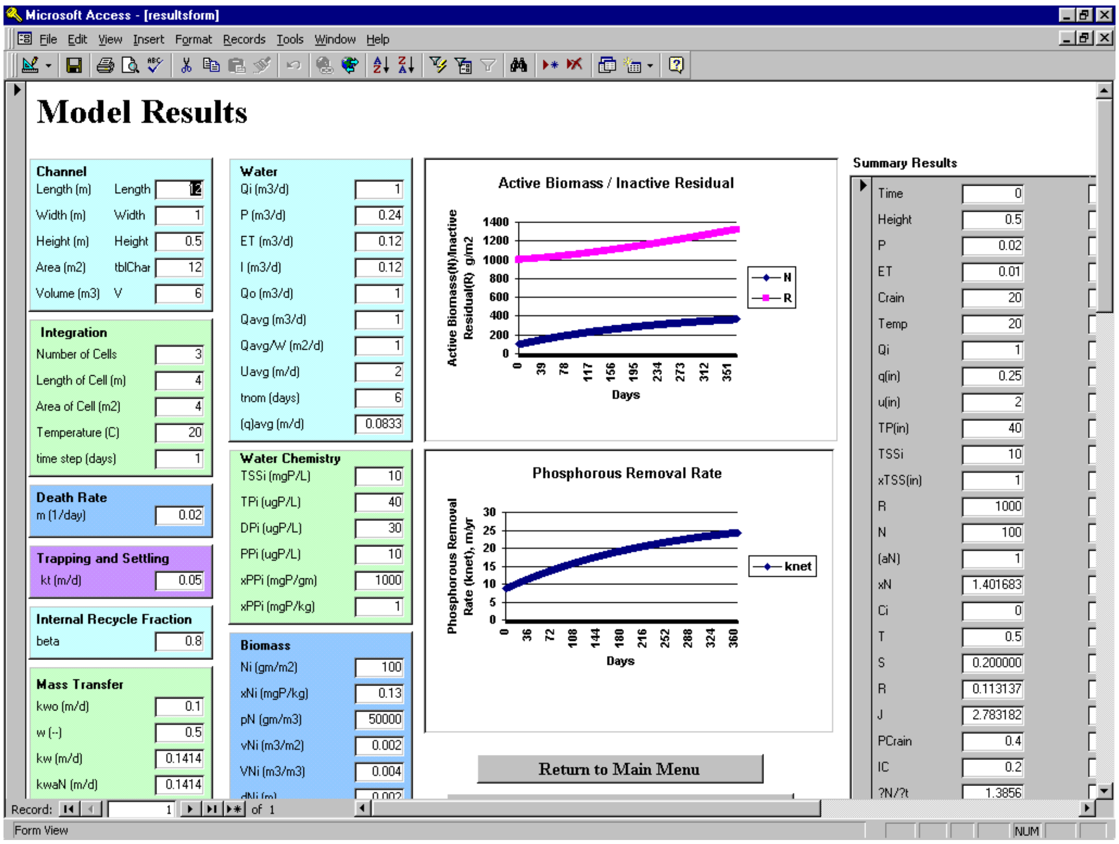
"Exit Model": Closes the database and exits the Microsoft Access application.

Changing Parameters

To change the input variables within the model, click on the "Model Variable Inputs" button. The following screen will display:

The variables are grouped according to general description. If the user of the model is unsure of a specific variable abbreviation, refer to the "Model Variable Definition" section of the model, or the end of this memo. To change a variable, simply click once within the corresponding box and change the number. Do not press return. Access will automatically update the tables when the new value is entered. If a mistake is made, select "Edit | Undo." When all changes have been entered, click "Run the Model." The model will take a few minutes to run. The mouse will change to an hourglass while running.

When finished, click "Take me to the Results" to open the results page as seen below:



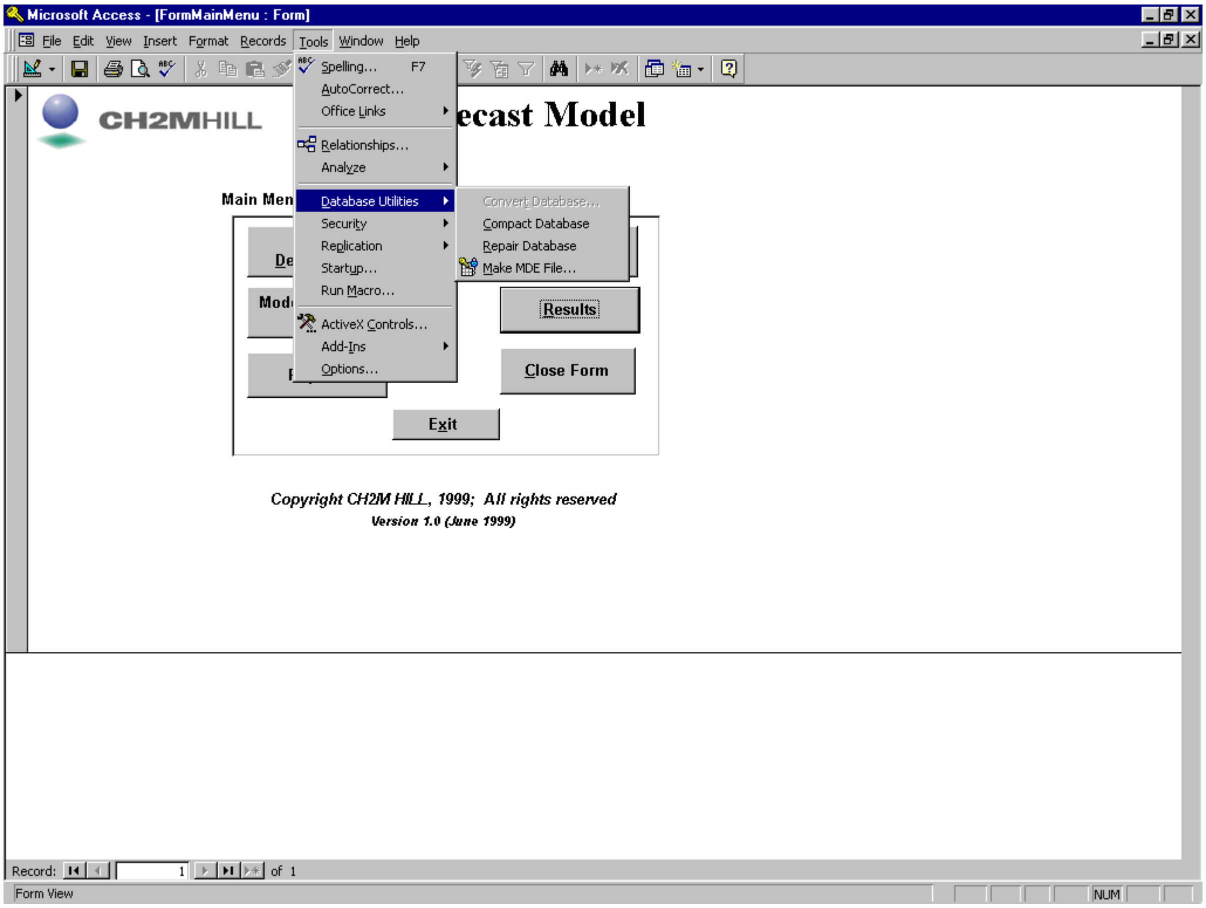
This page displays the input parameters, calculated results, plots of active biomass, inactive residual, and the phosphorous removal rate over time, and a summary results showing values for the first and last day of the model for comparison. If the model results are not as expected, the bottom button (not seen above) will return the user to the input page to make changes and rerun the model.

Printing Reports

This option is not yet fully developed, however it is expected it will allow the user to print results in a designed layout. It will also allow the user to choose from the model results stored in the database to create comparison tables or charts. The output from this section will be designed to be acceptable for inserting into publications.

Other concepts

An important concept when dealing with databases is the Repair and Compact utility. This is what keeps a large database in a surprisingly small space. It is suggested the database is Repaired/Compacted on a regular basis to keep the model running most efficiently. To do this, select Tools|Database Utilities from the Access drop down menus. Select first "Repair Database."



Microsoft Access will change the screen to a dialog box confirming the database was successfully repaired. Return to the Database Utility menu and select "Compact Database" to complete the operation.

Changing the Model Framework

The above concepts are all a user need know about Access to successfully manipulate the model. However, if changes to the programming of the model are desired, the following pages provide a reference to the calculations performed and their location. Table 1 defines important variables, while Table 2-xx display the calculations performed within each query and the formulas involved.

Model Framework

Table 1 Variable Definitions

Definition	Abbreviation	Units
Algal Biomass Standing Crop	N	gm/m2
Average Annual Gross P up take Rate Constant	kgross	m/yr
Average Annual Net P uptake Rate Constant	knet	m/yr
Channel Height	h	m
Channel Length	L	m
Channel Width	W	m
Concentration of Phosphorus is precipitation	Crain	ug/l
Concentration of SRP in cell	C	ug/l
Death of Algal Biomass	D	gm/m2/d
Death Rate	m	1/d
Density	ρR	g/cm3
Evapotranspiration	ET	m/d
Fraction of mat as P	Xn	mg/gm
Fraction of deposited particles that is P	XT	none
Fraction of inactive biomass that is P	Xr	none
Fraction of TSS as P	XTss	none
Growth of Algal Biomass	G	gm/m2/d
Hydraulic Loading Rate	q	m/d
Inactive Biomass	R	gm/m2
Infiltration	I	m/d
Inflow	Qi	m3/d
Internal Recycle Fraction	b	none
Mass Transfer of SRP into algal biomass	J	mgP/m2/d
Maximum concentration of SRP	Cmax	ug/l
Number of Cells	?N	none
Particulate Deposition	T	g/m2/d
Particulate Phosphorus	Cp	ug/l
Phosphorus Transfer Coefficient	kwo	m/d
Power Coefficient for Velocity Dependent Phosphorus Uptake	w	none
Power Coefficient for Velocity Dependent Resuspension	r	none
Power Coefficient for Velocity Dependent Sloughing	s	none

Table 1 – Variable Definitions (continued)

Definition	Abbreviation	Units
Precipitation	P	m/d
Residence Time	tnom	days
Resuspension Coefficient	kro	m/d
Resuspension Flux	RxR	mgP/m2/d
Settling Rate	kt	1/d
Slough rate constant	kso	gm/m2/d
Sloughed Algal Biomass	S	gm/m2/d
Time Step	?t	days
Total Phosphorous	TP	ugP/L
Total Suspended Solids	TSS	mgP/L
Velocity	U	m/d

Table 2 Constants Only Query

Variable	Calculation
A	=L * W
V	= L * W * h
Lcell	= L / NCell
DPi	= TPi – TSSi
xNi	= xNi / 10000
ρN	= 1000000 * ρN
AN	= aN / h
xR	= xR / 1000
ρR	= 1000000 * ρR
AR	= aR / h
u(in)	= Qi / (W * h)
T	= kt * TSSi
PCrain	= P * Crain
IC	= I * Crain

Table 3 CalcsandConst1 Query

Variable	Calculation
Acell	= Lcell * W
P	= P * A
ET	= ET * A
I	= I * A
PPi	= TPi – DPi
vNi	= Ni / ρN
vRi	= Ri / ρR

Table 4 CalcandConst2 Query

Variable	Calculation
Qo	= Qi + P – ET – I
xPPi	= 1000 * PPi / TSSi
xPPi(c)	= xPPi / 1000
VNi(c)	= vNi / h
VRi(c)	= vRi / h
q(in)	= Qi / Acell
TP(in)	= DPi + PPi
xTSS(in)	= PPi / TSSi
Q(out)	= Qi + Acell * (P – ET – I)

Table 5 CalcandConst3 Query

Variable	Calculation
Qavg	= average (Qi, Qo)
Qavg/W	= Qo / W
δNi	= VNi(c) / AN
δRi	= VRi(c) / AR
q(out)	= Q(out) / ACell
u(out)	= Q(out) / (W * h)
qCin	= q(in) * DPi

Table 6 CalcandConst4 Query

Variable	Calculation
Uavg	= Qavg / (W * h)
tnom	= V / Qavg
qavg	= Qavg / (L * W)

Table 7 CalcandConst5 Query

Variable	Calculation
kw	= kwo * ($Uavg^{w}$)
kr	= kro * ($Uavg^{r}$)
S	= kso * aN * (average Uin, Uout)^{s}
R	= kro * aR * (average Uin, Uout)^{r}
C(out)	=(PCrain+q(in)*C(in))/(q(out)+I+kwo*aN*(average Uin, Uout)^{w}
ks	= kso * ($Uavg^{s}$)

Table 8 CalcandConst6 Query

Variable	Calculation
kwaN	= kw * aN
kwaN(c)	= 365 * kwaN
kraR	= kr * aR
ksaN	= ks * aN
J	= kwo* aN * (average Uin, Uout)$^{w*(Cout-Ci)}$
qC	= q(in) / C(out)
sum in	= qCin + PCrain
qCpin	= q(in) * PPi
TSS(out)	= qC + qCp + IC
TxT	= T * xTSS(in)
RxR	= R * xR
xN	= if (C(out) > Cmax, 4, a * exp$^{(b*C(out))}$)

Table 9 CalcandConst7 Query

Variable	Calculation
Cp(out)	=q(in)*PPi + R*xR + S*xN – T*xTSSin
SxN	= S * xN
sum out	= qC + IC + J
TP sum in	= qCin + PCrain + qCpin

Table 10 CalcandConst8 Query

Variable	Calculation
TP(out)	= C(out) + Cp(out)
xTSS(out)	= Cp(out) / TSSout
qCp	= q(in) * Cp(out)

Table 11 CalcandConst9 Query

Variable	Calculation
kgross	= 365*(q(in)*TPin – (q(out)*TPout*(Average TPin, TPout)))
TP sum out	= qC + qCp + IC

The next set of Queries is dependent upon time. Data from the time interval is temporarily written to a table so it may be drawn upon during the next time step. ($_{t-1}$) indicates a value from the previous time step.

Table 12 timedependent#1 Query

At time step = 0, N and R are the inputs Ni and Ri

Variable	Calculation
R	= R_{t-1} + (?t * $(?N/?t)_{t-1}$)
N	= N_{t-1} + (?t * $(?N/?t)_{t-1}$)

Table 13 timedependent#2 Query

Variable	Calculation
RxR	= R * xR
NxN	= N * xN
D	= N * m

Table 14 timedependent#3 Query

Variable	Calculation
G	= xN / J + beta * D
xND	= xN * D
?RxR/?t	= T*xTSSin – R*xR + (1-beta)*D*xN

Table 15 timedependent#4 Query

Variable	Calculation
?N/?t	= G – D – S
GxN	= G * xN
knet	= 365((?RxR/?t)/(Average TPin, TPout))
betaxND	= beta * xND
(1-beta)xND	= (1-beta) * xND

Table 16 timedependent#5 Query

Variable	Calculation
sum biomass	= GxN – xND – SxN
sum residuals	= TxT – RxR + (1-beta)xND

All other queries write the resulting calculations to tables for use in either future calculations or results tables.